TRADE LIBERALIZATION AND TOTAL FACTOR PRODUCTIVITY RELATIONSHIP IN MOZAMBIQUE

By

Jaquelina Natal Calisto Cheveia

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

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2014

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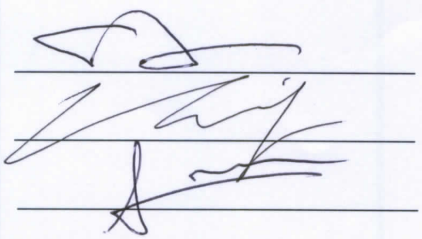
Committee in charge:

Professor Shun WANG, Supervisor

Professor Yoon C. CHO

Professor Si Wook LEE



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ABSTRACT

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Jaquelina Natal Calisto Cheveia

By employing Vector error correction method (VECM), which takes into account co-integration among time series variables, current paper consists in a case study of Mozambique with a time series sample from 1980-2010, it attempts to examine trade liberalization and total factor productivity relationship, distinguishing from others papers that mostly use panel and cross-section data and employ methods as first differences, as well as random and fixed effects.

Main findings suggest that effect of trade liberalization on total factor productivity in Mozambique is ambiguous and dependent on its interaction with other variables such as human capital. Without including interaction term, trade liberalization was found to impact positive and significantly total factor productivity, however when interaction term between human capital and trade openness was introduced as well as when including both interaction term and break dummy variables to account for structural changes, trade openness coefficient became negative as well as interaction term and human capital was positive. Some authors suggest that this relationship may be non-linear, implying that there is probably a threshold for human capital and trade openness, and it will consequently affect total factor productivity in different ways, depending on the levels of human capital and trade openness. Therefore, results with interaction term might be explained by the existence of high levels of trade openness and low levels of human capital in Mozambique which generates low absorption capacity of knowledge coming from abroad and inability to deal with strong international competition.

Key-words: Trade liberalization, total factor productivity, VECM and Mozambique.

DEDICATORY

To my parents, Calisto and Maria Natal,

and to my beloved Marcelino.

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I acknowledge God who guided me through this thesis writing and only He scattered light when it was dark and full of uncertainties. I'm grateful for the support of my family, my dear parents who always believed in me, and were able to fight in order to provide everything, me and my siblings needed, and above all, to fight for our education. Mom and Dad, you did a good job!

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ACRONYMS AND ABBREVIATIONS

DEA: Data Envelopment Analysis

DID: Differences-in-Differences

FDI: Foreign Direct Investment

EBA: Extreme bound analysis

ERP: Effective rate of protection

GDP: Gross Domestic Product

GMM: Generalized Method of Moments

IMF: International Monetary Fund

M2: Money and *Quasi*-money

OECD: Organization for Economy Cooperation and Development

OLS: Ordinary Least Square

QLR: Quandt Likehood ratio

SSA: Sub-Saharan Africa

TFP: Total factor productivity

TOP: Trade openness

VECM: Vector error correction model

WB: World Bank

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1. Introduction

In the 1970's, following the Oil Crisis, the Bretton Wood Agreements which used to govern exchange rates (Bretton Woods Golden Standard), international monetary cooperation and world trade arrangements, collapsed, and international architecture started to be molded toward flexible exchange rates and free-markets. Bretton Wood Institutions (International Monetary Funds and World Bank) from then on have been putting emphasis on international cooperation, capital mobility, free trade flow (trade liberalization, by reducing barriers to international trade), market-led development and country institutional reforms towards economic liberalization. The main argument was that free trade would bring benefits through specialization either in labor-intensive activities or capital-intensive activities, enjoying the free movement of goods and enhancing "comparative advantage".

Many critics argue that these institutions are US or Western tools to impose economic policies which support Western interests, furthermore, arguments suggest that free market reform policies, which the IMF and WB advocate, in reality, generally, are harmful to economic development when implementation is not appropriate (for instance, too quick implementation which generates a shock for the economy or wrong sequence) or the environment is not favorable (e.g. existence of infant industries, less competitive economies).

In this context, during the 1980's, more precisely in 1987, Mozambique joined IMF and WB and reforms were introduced, representing a great sift from a state-led economy to a market-led economy. One of the sectors that suffered from trade reforms was the infant industry of cashew nuts. As the export tariffs on raw nuts reduced, trader licenses were eliminated to increase traders' number, and higher prices were expected to be paid by traders to smallholder producers, results ended up reverted as gains of price increase were retained by traders rather than farmers because major exporters were organized and coordinated prices applied to farmers, and held additional profit from higher cashew prices. Thus, the net gains of farmers were low and offset by the costs of unemployment due to the decline of processing sector (Kanji et al. 2004, pp 4-5).

One of the conclusions advanced was that promoting trade liberalization was unlikely to increase producers' benefits in Mozambique without a range of supporting policies ensuring market

infrastructures, availability of goods and fair prices, appropriate technology, and institutions at all levels (local and central) (Kanji et al. 2004, pp 4-5).

The debate concerning the relationship between trade liberalization and total factor productivity has not reached a clear consensus. While some authors are assertive about a positive and significant relationship such as Nataraj (2011), Gustafsson and Sergerstrom (2010), Isaksson (2007), Melitz (2003), Lisboa et al. *(*2010), defending trade openness benefits such as economies of scale and specialization, access to advanced technology, knowledge spill-overs, sector- level turnover dynamics (entry of more productive firms and exit of less productive firms which increases average productivity), access to foreign market of goods, services and capital, increased efficiency as a result of increased competition (learning-by-exporting hypothesis), and so forth. Other studies, on the other hand, were able to demonstrate an insignificant role of trade openness in total factor productivity as Haidar (2012), Alvarez and Lopez (2005), Kraay (2002), Clerides et al. (1998), Hwang and Wang (2004), and Blalock and Gertler (2004). Furthermore, some authors as Mayer (2001), Isaksson (2001), Wei and Hao (2011), Pritchett (2001), considered the impact of trade liberalization as conditioned by the existence of absorption capacity of domestic country, namely: high level of human capital, physical infrastructure, institutional environmental (e.g. good governance, rule-of-law), financial development, saving rate, industrial and services development.

Most studies have been focusing in cross-country analysis rather than country-specific analysis, particularly focused in Mozambique. Therefore, to avoid generalized and one-fit conclusions, present study assess trade liberalization's effect on total factor productivity in Mozambique, with a sample of 31 years from 1980-2010, and base its conclusions in a time-series analysis using Vector Error-Correction Model which considers co-integrated variables with a stable long-term relationship.

1.1. Case study motivation and relevance

Total factor productivity is, generally, part of the production function and it has implication to economic growth. TFP can be considered as the "best expression" of the efficiency of economic production and the long-run expectation of output increase (Statistics Canada 13-568:50-51 cited

from Lipsey and Carlaw, 2001). Total factor productivity can increase due to factor efficiency and/or technological progress, and trade liberalization through it different channels can affect both factor efficiency (managerial progress, increased competition, economies of scale, and so forth) and technological progress (knowledge transference, cross-country technology, and so forth). Thus, it is important to observe which benefits and drawbacks advent from trade liberalization in a country-level perspective (Mozambique economy) rather then a cross-country analysis, due to country specific features; be able to bring relevant results and contribute with accurate inferences regarding forms to prevent Trade openness to cause harm to Mozambican economy and capitalize benefits from such openness, being these the motivation of this study.

Present study is by itself relevant, because it attempts to determine the impact of trade liberalization on total factor productivity in Mozambique, considering other variables, control variables, such as human capital, industrial development, financial development, public expenditure, foreign direct investment and household consumption ratio. By using a time series analysis and Vector Error-Correction Model, and so contributing to existing knowledge on trade openness and total factor productivity, in particular, in country-specific analysis. Moreover, present study evaluates how these variables are connected and integrated to determine total factor productivity and ultimately, economic growth, giving support to future policies design to capitalize benefits from trade openness and reduce negative effects.

1.2. Research Question and Problem Statement

How did trade liberalization affect total factor productivity in Mozambique during 1980-2010?

Many papers have been focusing in total factor productivity and its determinants in a cross-country perspective. One of the determinants that have been gaining relevance is trade openness as well as initial GDP per capita, capital formation, government expenditure, consumption ratio, foreign direct investment and so forth. Trade openness which is the reduction and even abolition of trade barriers such as quotas and tariffs represents an important step of any economy that wishes to achieve economic liberalization (international liberalism) and greater integration with world markets and economy. In this sense, trade liberalization has been associated with increasing levels of total factor productivity, and consequently affecting positively economic

growth, through different channels such as: (i) knowledge spill-over effects across and within countries (Feder 1982, Grossman and Helpman 1991a); (ii) economies of scale as a result of domestic market amplification (Grossman and Helpman 1991b); (iii) presence of import discipline hypothesis which suggests an increased competition inboard economy (Greenaway and Milner 1993, Aghion et al. 1997); (iv) increased inputs availability (Grossman and Helpman1991a, Nishimizu and Robinson 1986, Rivera-Batiz and Romer 1991a, 1991b; Quah and Rauch 1990); (v) efficiency in factor-allocation across different sectors (Grossman and Helpman 1991a).

However, depending on each country specification (absorption capacity, physical and social infrastructures, economic environment, governance and so forth) and how trade liberalization is implemented (industries and sectors that should be affected first by trade liberalization, degree of trade liberalization, government incentives to enter in international markets, and so forth), trade liberalization can either advent positive either negative effects on country levels of productivity and ultimately in economic growth. Thus, assessing trade liberalization's effect on total factor productivity in a country level (Mozambique) and ways to reap more benefits from trade openness through different channels as mentioned above are the main focus and purpose of this study.

1.3. Research Objectives

Main Objective

- To assess the impact of trade liberalization on total factor productivity of Mozambique from 1980-2010.

Specific Objectives

- Develop econometric model and time series analysis for total factor productivity as dependent variable, trade liberalization as explanatory variable and control variables;

- Compare results between Vector Error-Correction Model and OLS regression;

- Derive specific policy implications with the intent of reducing negative effects of trade openness and optimize benefits.

Present study is divided in the following parts: first, the literature review, showing previous work on total factor productivity and trade liberalization, and developing hypothesis to be tested in current paper; second, data and model specification are developed; third, results from VECM analysis are presented; forth, conclusion and further recommendations are presented; and finally, references are provided in last section.

2. Literature Review and Hypothesis statements

2.1. Trade liberalization and Total factor productivity: Definition

Trade openness, using the concept by Lee (2005) consists in steps towards free trade (total removal of constraints) by increasingly reducing restrictions or barriers on the free exchange of goods, such barriers can be tariffs (e.g. duties and surcharges) as well as non-tariff (e.g. quotas and licenses). Even tough some studies from World Bank (e.g. Papageorgiou et al. 1990) consider trade liberalization as "any act that make trade regime free of protection for imports and exports goods" synonymous to no-government intervention on trade system; some studies (Shafaeddin 1991a) argue that liberal trade regime can be achieved with a certain level of protectionism on imports and exports, raising the distinction between outward orientation and liberal trade system (Shafaeddin 2005).

With respect to total factor productivity, this concept was introduced by Solow (1956), TFP was then, considered as "manna from heaven" in its aggregate production function; later concept of TFP was developed under the endogenous growth models by Romer (1986) and Lucas (1988) which considers technological progress as the main determinant of total factor productivity growth. Total factor productivity was defined as the residual, it combines any differences in the production function which can not be attributed to inputs, measuring the shifts in the production function caused by many factors such as technological progress, variations in demand, change in input-factor shares, organizational and institutional variations, and so forth (Hulten 2001). Due to the way TFP is calculated as a "left-over" factor, it is hard to sort the "pure" TFP values, thus TFP is seen as "the measure of our ignorance" (Hulten 2001, Jones and Wollrath 2013). Overall, TFP can be considered as the "best expression" of the efficiency of economic production and the long-run expectation of output increase (Statistics Canada 13-568:50-51 cited from Lipsey and Carlaw, 2001).

The debates concerning the relationship between trade liberalization and total factor productivity have not reached a clear consensus. While some authors are assertive about a positive and significant relationship such as Nataraj (2011), Gustafsson and Sergerstrom (2010), Isaksson (2007), Melitz (2003), Lisboa et al. *(*2010), defending trade openness benefits such as economies of scale and specialization, access to advanced technology, knowledge spill-overs, sector- level turnover dynamics (entry of more productive firms and exit of less productive firms which

increases average productivity), access to foreign market of goods, services and capital, increased efficiency as a result of increased competition (learning-by-exporting hypothesis), and so forth. Other studies, on the other hand, were able to demonstrate an insignificant role of trade openness in total factor productivity as Haidar (2012), Alvarez and Lopez (2005), Kraay (2002), Clerides et al. (1998), Blalock and Gertler (2004), and Hwang and Wang (2004). Furthermore, some authors, Mayer (2001), Isaksson (2001), Wei and Hao (2011), Pritchett (2001), considered the impact of trade liberalization as conditioned by the existence of absorption capacity of domestic country, namely: high level of human capital, physical infrastructure, institutional environmental (e.g. good governance, rule-of-law), financial development, saving rate, industry and services development.

2.2. Trade liberalization and total factor productivity: Hypothesis development

Following some studies, for instance, Gustafsson and Sergerstrom (2010) tried to show the relationship between trade liberalization and total factor productivity by using a sector-level model; their findings suggest that trade openness frequently induce firms which are less productive to exit and spur more productive firms (non-exporting) to enter the foreign market (incurring to a fixed costs), contributing for an average increase in productivity; moreover trade openness effects on TFP regards inter-temporal knowledge spill-overs in R&D, if weak, trade openness promotes growth of productivity in the short-term and consumers end-up better off in the long-run; while, if spill-overs are strong, trade liberalization delays, in short-term, the growth of productivity, and in the long-term, consumers are worse off. Such conclusion corroborates with Melitz (2003) results which shows that trade openness enhance productivity growth in the short-run and in the long-run, consumers are left better-off.

Nataraj (2011) looked at the manufacturing sector in India, incorporating formal and informal firms, using a difference-in-differences (DID) strategy. The study's findings suggests that trade liberalization had net positive effects on average productivity, although the channel through which trade liberalization affects productivity is different between formal and small, informal firms. While 10% cut in final goods tariffs generate an increase in average productivity by 3.3%

driven by small an informal sector, the effect on formal sector was insignificant; a 10% cut in input goods tariffs induced 4.6% increase on average productivity in formal sector, mainly.

Moreover, Lisboa et al. *(*2010) analyzed productivity growth and trade liberalization in Brazil; with a sample of firms from 30 manufacturing sectors. In order to enable for "market power in product market", authors applied a methodology initiated by Hall (1988) and also adopted by some authors as Domowitz et al. (1988) and Harrison (1994). Their results suggest that trade liberalization affected productivity growth, mainly, through input market, its impact was sensed more in capital-intensive sectors as technology rather than labour-intensive sectors as natural resources, furthermore, the increase in mark-ups was seen to be caused by a reduction in input tariffs meanwhile, a reduction in output tariffs generated a decrease in mark-ups.

Turning attention to studies which argue an insignificant role of trade liberalization on total factor productivity, Haidar (2012), for instance, produced a study of the impact of trade liberalization on productivity exploring the hypotheses of self-selection and learning-by-exporting in India. The study found that: (i) between non-exporters and exporters, latter presented lower unit labour costs and higher productivity than former; (ii) firms that ultimately will become exporters performed better than the other non-exporters (self-selection hypothesis); (iii) there is no evidence that shows that preparation for exports, such as export subsidies, will improve productivity; and (iv) it is not found that entry into export markets generate/spur productivity (improvement hypothesis, learning-by-exporting hypothesis).

Results from Haidar (2012) corroborate with previous studies such as Blalock and Gertler (2004) for Indonesia, Kraay (2002) for China, Alvarez and Lopez (2005) for Chile, Clerides et al. (1998) for Colombia, Morocco and Mexico, which also argue that more productive firms self-select themselves to enter in exports market (self-selection hypothesis) but there is no evidence of increased productivity due to export activities (learning-by-exporting hypothesis). Additionally, Hwang and Wang (2004), while examining the impact of trade openness in total factor productivity in 45 manufacturing industries in Japan, using the extreme bound analysis (EBA), found an insignificant and ambiguous effect of trade openness and TFP growth.

With respect to Mozambique, the hypothesis developed in this study is:

H1: Trade liberalization in Mozambique, had an average positive effect on total factor productivity, in the period from 1980-2010, even though it was conditioned by low human capital level, low financial development, low industrial development, lack of physical capital, high level of consumption ratio.

2.3. Total factor productivity and control variables

a) Human Capital

As argued by Mayer (2001), trade has a direct impact on knowledge, the introduction of foreign technology in national economy, in particular, imports of machinery, equipment, R&D related material , which would have positive impact on TFP; meanwhile, transference of technology has an indirect impact on TFP. In these terms, exports activities should be considered to affect TFP as a result of learning (learning-by-export hypothesis), as well as influxes of foreign investment affects TFP by increasing gross capital formation (Isaksson 2007).

Even though such hypotheses regarding benefits of trade openness may hold true, one must consider human capital, as a factor that guarantees the adoption/absorption of technology from abroad (Nelson and Phelps 1966), as well as engender domestic technology (Romer 1990b; Aghion and Howitt 1998). Corroborating with the absorption hypothesis, Isaksson (2001) argued, using panel data analysis with 73 countries, that even though trade is significant for knowledge and technology acquisition, it will only have positive effects (direct and indirect) on productivity as long as there is high level of human capital. In addition, focusing on Chinese economy, Wei and Hao (2011) based on a panel data of about 30 provinces of China, tried to examine, empirically, the impact of human capital on TFP growth, by applying the fixed effects model. They considered both quantitative (e.g. average years of schooling, secondary and tertiary school enrolment) and qualitative (e.g. teacher-student ratio, share of government expends on education) measures of human capital. Their findings showed that, first, when using quantitative measures, human capital is significant and positively related to TFP growth, but when considering qualitative measures, human capital displayed to be unrelated to productivity growth.

On the other hand, some studies were able to find negative and statistically significant effects of human capital on total factor productivity such as Pritchett (2001), being the negative sign attributed for instance to human capital endogeneity (Krueger and Lindahl 2001) and inappropriate measures of human capital, generally usage of quantitative data rather than qualitative to express human capital (Bosworth and Collins 2003).

With respect to Mozambique, the hypothesis is developed considering low levels of human capital but positive trend (growth throughout the period), is:

H2: Human capital in Mozambique had an average positive effect on total factor productivity, in the period 1980-2010.

b) Industrial development

With respect to industry (industry value added), in order for technological progress and factor efficiency change take place, conditions must be satisfied initially, being one of them the accumulation of capital and labor (factor accumulation). Thus, the level of industrialization (proxy by percentage of industry value added to Gross Domestic Product) will tend to affect positively total factor productivity.

Romer (1986) used the concept of learning-by-doing, which assumes that experience with production and/or investment will add to productivity, furthermore, the knowledge spill-over process of learning by one worker or firm and transference to other workers or firms will enhance productivity. Additionally, Research and Development (R&D), very often takes place at firm or industry level, promoting productivity and ultimately, economic development (Isaksson 2007). Thus a greater capital accumulation of the aggregate of past production (industry growth) ameliorates the level of technology for each worker or firm (TFP improvement) (Barros and Sala-i-Martin 2004).

However, literature supposes also a reverse causality, were total factor productivity induces industry value added growth, as total factor productivity constitutes part of the production function, patent in the endogenous growth models of Romer (1986) and Lucas (1988).

During 1976-1992, Mozambique faced a Civil War which destroyed most productive infrastructures such as bridges, plants, telecommunications and so forth. This event reduced the chance of local industries to develop and total factor productivity growth was substantially affected (negatively) by it. Only after the war, with the signature of the Peace Act in 1992, efforts to raise domestic industry start taking place. Thus, lack of industrial development could indeed hamper total factor productivity growth as it needs a "platform" to grow from, and factor accumulation must come before innovation (TFP improvement) such as argued by Barros and Sala-i-Martin (2004).

Present paper does not consider reverse causality, even though it could be patent. Thus, for the case of Mozambique, due to low levels of industrial development, the hypothesis developed is:

H3: Industrial development in Mozambique had an average negative effect on total factor productivity.

c) Financial development

Financial development plays a relevant role as a contributor of TFP growth, as for Goldsmith (1969) by increasing marginal productivity of capital, as well as by promoting the efficient allocation of capital, ultimately, increasing saving rate (aggregate) and level of investment in domestic economy (McKinnon 1973). But, as literature supports, capital stock faces diminishing returns to scale, restraining positive effects of financial development on productivity growth and consequently, economic growth (Jeanneney et al. 2006).

Jeanneney et al. *(*2006), while employing the Generalized-Method-of-Moment system estimation (GMM, from herein), to explore the effect of financial development on productivity growth in China using a panel data (29 provinces, from 1993 to 2001), was able to show that financial development had a positive impact on productivity growth, mainly, due to efficiency improvement rather than technical progress.

Additionally, Greenwood and Jovanovic (1990) and Bencivenga and Smith (1991) developed in their studies an endogenous model to investigate the effects on financial intermediation on productivity growth; former, underlined two important ways through which financial

intermediation affect TFP and enhance economic growth, namely, exploring information of investment projects and augmenting efficiency through funds allocation in projects with relatively higher returns expectation; while latter argued that financial intermediation improves fund's allocation efficiency and ultimately contributes to productivity growth by spurring liquidity and increasing risk diversification (cited in Jeanneney et al. 2006).

Moreover, Ben-Habib and Spiegel (2000) found that financial development is positively correlated with total factor productivity as well as capital accumulation; by employing the Generalized Method of Moments, they attempted to show in their study if financial development affects economic growth through only the traditional channels, factor accumulation (labour and capital accumulation) or also through technological progress and knowledge creation (productivity). Yao (2011), while studying Chinese economic growth efficiency and controlling for variables such as: capital formation rate, foreign direct investment, government intervention and urbanization level, the author found that financial intermediation in China was able to promote TFP growth, even without considering in the sample Beijing, Tianjin and Shanghai.

Furthermore, the study by Rajan and Zingales (1998) showed that industries which use more external finance (external finance to be understood as all funds generated not internally, according to firms' internal resources) grow faster in economies with higher levels of financial development; financial intermediation, in this case, results to be a strong contributor to TFP by providing financial support to the development (R&D expenses and new technologies) and expansion of such industries.

In contrast to the arguments presented above, some authors argue that the relationship between financial development and total factor productivity is in fact non-linear and even dependent upon levels of development of each country. For instance, Rioja and Valev (2004) found in their study inconclusive and even negative relationship between financial development and productivity growth, using as sample Latin America and other developing countries during the decades of 1970 and 1980. The unregulated financial liberalization and experience of government bailout were accounted for the negative relationship between level of financial development and productivity growth. Moreover, Cecchtti and Karroubi (2012), using a sample of fifty (50)

countries from advanced to developing countries, found that the relationship between total factor productivity and financial development was indeed non-linear. Financial development contributes positively to total factor productivity growth only till a certain point, for higher levels of financial development (in terms of size of financial intermediation), it can become a burden to total factor productivity growth, generating a reverse effect.

After joining Bretton Woods institutions in 1987, Mozambique went from a socialist to a capitalist country, being forced to operate some reforms towards economy liberalization such as privatization of state owned companies, liberalization of financial sector, liberalization of trade, controls over public expenses, and so forth. In this context, in 1992, the Central Bank of Mozambique seized its role as a Commercial Bank, starting to act exclusively as Central Bank and transferring its commercial role to Commercial Bank of Mozambique (CBM, in English). In 2000, the country faced a generalized financial crisis as a result of high levels of credit default, especially, with respect to two of the main banks at the time, Commercial Bank of Mozambique and Austral Bank. In order to avoid financial collapse, in 2001, Mozambican government bailed-out a debt of over USD 130 million correspondents to over 4% of Gross Domestic Product.

Hence, considering the redirection of public resources to save financial sector from a breakdown and prevalence of an inefficient financial sector during the period in analysis, 1980-2010, it might suggest the following hypothesis development:

H4: Financial sector in Mozambique had an average negative effect on total factor productivity, in the period 1980-2010.

d) Government expenditure

In some countries, it is possible to observe that the government is responsible for the investment in public capital, especially, physical infrastructure. Physical infrastructure consists in one of the requirements to build up productive capacity by accumulating resources (capital accumulation) and enhancing productivity. Public investment does not include only physical infrastructure but also social infrastructure such as investment in education and health. Thus, capital formation allows: reduction of transaction costs, expansion of productivity capacity, increase of efficient

use of resources; and social investment allows human capital accumulation (Eisner 1986, Aschauer 1989, Isaksson 2007).

For instance, when examining the behavior of productivity in United States, its variations as a result of public-sector capital accumulation and the flow of government expenses, Aschauer (1989) concluded that non-military or public expenses in "core" infrastructures such as roads, highways, airports, water systems, sewers, were able to significantly explain changes in productivity, moreover, the author suggested that the productivity slowdown between 1970's and 1980's could be explained by a net reduction in public capital stock.

However, some authors also argue that public expenditure may do harm to the economy as public investment may displace private investment as a result of increased interest rates due to limited capital resources, this is the so called crowding-out effect (Isaksson 2007).

By applying a production function approach to disaggregated data covering 14 OECD countries, Hansson and Henrekson (1994), found that government consumption, transfers and total spending affect negatively the growth of total factor productivity, meanwhile, government expenses related with education produced positive effect on TFP but its investment was found to no effect on total factor productivity.

Thus, concerning Mozambique, public-sector expenditure toward "core" infrastructure is needed to enhance productive capacity because such areas do not attract private-sector investment, null hypothesis developed is:

H5: Government expenditure in Mozambique had an average positive effect on total factor productivity, in the period 1980-2010.

e) Foreign direct investment

With respect to foreign direct investment, some studies consider ambiguous/mixed, as it goes from positive to negative, the relationship between FDI and total factor productivity. For instance, Aitken and Harrison (1999) found that FDI enhanced productivity within plants in

Venezuela which received foreign investment while lowering that of domestically owned plants, due to negative spill-over effects from foreign firms to domestic firms (market-stealing effect), hence, net impact of FDI on productivity was significantly small. Likewise, Gorg and Greenaway (2004), by employing a micro-level data analysis, found that productivity growth tended to be negative as a result of the absence of knowledge spill-overs from foreign companies to domestic ones.

Furthermore, Bitzer and Gorg (2009), while controlling for national and international knowledge spillovers, and applying for industry and country data from OECD countries (17), observed, on one hand, that inward FDI flows had an average positive effect on total factor productivity, even though for some countries the effect was negative; on the other hand, outward FDI flows had an average negative effect on total factor productivity but there were countries which presented positive effects such as France, United States, United Kingdom, Sweden and Poland.

Nevertheless, there are studies which argue that FDI its positive effects will depend on local conditions and environment (e.g. policy environment, economic-financial markets, social-human capital). For instance, Alfaro et al. (2006) developed a linkage between total factor productivity, financial development and FDI; findings showed that factors accumulation (human capital and physical capital) was not the main channel through which FDI was affecting TFP and economic growth, instead, they discovered that high levels of financial development where related to TFP improvements by knowledge spill-overs, transference of technology, new processes and managerial skills, and by promoting vertical and horizontal linkages between foreign and local firms as well as physical capital formation, employee training; therefore, arguing that financial markets play an important role by allowing countries to reap the advantages of direct inflows of foreign capital (FDI), specially, through TFP improvements.

Additionally, Baltabaev (2013), by making use of GMM in a panel data of 46 countries, was able to find that FDI affected positively total factor productivity growth (FDI measure used was the stock of FDI rather than current values), but that this positive effect was conditioned by the level of absorptive capacity of recipient countries when considering technology gap between technology leader and followers, meaning, that countries with larger technological gaps would reap more benefits from FDI.

In this sense, regarding Mozambique its local conditions and environment, specially, the absence of knowledge spill-overs from foreign companies to domestic ones during the period in analysis, the hypothesis developed is:

H6: Foreign direct investment in Mozambique had an average negative effect on total factor productivity.

f) Household Consumption (opposed to saving rate)

In the literature, the "Golden Rule of capital accumulation" concept was developed to assess the saving rate that would maximize steady-state consumption per person (Barros and Sala-i-Martin 2004).

By supporting the theory, Danquah et al. (2011) explored the impact of a wide set of variables as determinants of TFP using Data Envelopment Analysis (DEA) [1] approach and Bayesian Averaging technique [2]. According to the Bayesian robustness check, beside unobserved heterogeneity (i.e. fixed effects), two variables were found to be robust determinants of total factor productivity growth through efficiency change, namely, consumption share (saving share) and trade openness, which were negative and positively, related to TFP growth, respectively; meaning that countries with lower consumption share (high saving rate) and high degree of trade openness (more outward-oriented trade) would enhance productivity growth through efficiency change, catching up faster the frontier.

However, recent studies, unveil a reverse causality in the relationship between saving rate (consumption share) and total factor productivity. According to Ramsey model (Barro and Sala-

[1]Data Envelopment Analysis (DEA) approach was proposed by Färe et al. (1994). This approach assumes the existence of inefficient behavior and provides a production frontier which represents the maximum achievable level of production; furthermore, DEA approach is able to decompose TFP growth into its components: technological progress (innovation) and technical efficiency (i.e. technological adoption by input factors).

[2]The Bayesian Averaging technique considers models and parameters as unobservable, and observable data is used to calculate distributions. The model assumes model uncertainty, in the sense that, all possible models are considered (all possible regressions), minimizing parameters' biases and reporting a weighted average as the estimate of interest. A researcher using such approach knows that the true model is not known and the best is to consider all possible alternatives, avoiding basing the conclusions on incorrect regressions. Furthermore, the model allows the creation of variables rank according to their robustness. The Bayesian Averaging technique is also known as agnostic approach, contrary to classical estimation (single model/regression).

i-Martin 2004), variations in productivity growth rate will have an effect on the income of households and the rate of return of capital, consequently, affecting income and substitution effects on decisions concerning consumption-saving. On one hand, if the elasticity of inter-temporal substitution (substitution effect) is high, an increase in productivity growth allow a higher steady-state saving rate and a higher rate of return to capital per effective worker, which means a lower demand for saving as a result of less need of capital per worker; on the other hand, a high productivity growth that allows for more saving, would permit investment without forsaking consumption (income effects).

Following this argument, İşcan (2010) tried to examine if changes in productivity growth were affecting consumption-income ratio in the United States, by considering a dynamic general equilibrium model and the income and substitution effects. The model was able to show that medium-term variations on productivity growth accounted for changes in consumption-income ratio during some periods such as the noteworthy decrease in the saving rate in U.S. from 1980 to 2000, but missed to account for the constant and high consumption-income ratio in the period 2000-2006.

For present paper, it is considered that reverse causality is not patent, due to lack of evidence that total factor productivity indeed enhanced saving rates (decrease of consumption-ratio share). Thus, for the case of Mozambique, the hypothesis developed is:

H7: Household consumption-income ratio in Mozambique had an average negative effect on total factor productivity.

In this sense, in addition to the relationship between trade liberalization and total factor productivity, current paper also considers controls variables namely, human capital, industrial development, financial development, government expenditure, foreign direct investment, consumption-income ratio, which may have also impacted total factor productivity in Mozambique, during the period 1980-2010. Following section will detail data and methodology used in order to test for hypothesis developed above.

3. Data and Methodology

The present work attempts to assess the relationship between trade liberalization and the total factor productivity (TFP) in Mozambique, which ultimately influences economic growth, during the period 1980-2010 (thirty-one years analysis).

In order to achieve the goal established, it is needed to create and develop the model with the relationship expected. In first place, Total Factor Productivity (TFP) measure was calculated using the Cobb Douglas production function; second, to measure trade liberalization, trade volume to Gross Domestic Product share was used as a proxy, as well as proxies for control variables were defined; third, model building, considering trade liberalization proxy as independent/explanatory variable, TFP as dependent variable, and control variables: human capital (average years of schooling), industrial development (industry value added share of GDP), financial development (ratio of Monetary Mass-M2 to GDP), government expenditure to GDP share, Foreign Direct Investment to GDP share and Household consumption share of GDP.

3.1. Data

a) Total Factor Productivity

The dependent variable, total factor productivity was calculated based on Cobb Douglas's aggregate function[3]:

$$Y_t = K_t^{\alpha} * (A_t L_t h_t)^{1-\alpha} \qquad (3)$$

The Total Factor Productivity is measured as:

$$A_t^{1-\alpha} = TFP = \frac{y_t}{k_t^{\alpha} * h_t^{1-\alpha}} \qquad (4)$$

Where:

Yt represents the Gross Domestic Product (GDP) along the time t (t=1980…2010); **y_t** is per capita GDP, obtained by dividing Gross Domestic Product (GDP) to total labor force; ***Kt***

[3] Barros, Robert J., and Sala-i-Martin, Xavier. 2004 "Growth Models with exogenous saving rates", in *Economic Growth*.

represents the capital stock of Mozambican economy during time t (t=1980…2010); A_t (1-α) is the total factor productivity during time t (t=1980…2010); L_t is the amount of labor force in the country during time t (t=1980…2010); h_t stands for human capital per capita during time t (t=1980…2010).

Data from Gross Domestic Product (GDP), labor and investment were obtained from *World Bank Database*, for the years concerned. In order to calculate human capital per capita were obtained from *Barro-Lee database* (version 3), the average school enrollment[4]. Even though, data for capital stock is not available in *World Bank Database*, it is possible to calculate it by using their Investment data and applying the perpetual inventory method[5] (the growth rate is the geometric average growth rate of the first decade of investment and the depreciation rate of physical capital is assumed as 6%, as according to literature).

b) Measures of Trade Liberalization

The most common and simplest measure of trade liberalization/trade openness consists in the ratio of trade volume (sum of exports and imports) to Gross Domestic Product, so called trade ratio. The total exports and imports of goods and services, as well as data of GDP (constant US$) were obtained in *World Bank Database*[6].

David (2007) denotes three other measures of trade openness, namely: (i) adjusted trade flow, which use the deviation of the actual trade flows from the expected free-trade flow, representing the outcomes that would have been true if more free trade policies were adopted; (ii) price-base, which calculates openness by looking at price distortions in goods markets and currencies

[4] Relative to human capital per worker, it can be obtained by using the years of schooling (st) and the respective productivity of human capital (Ø), thus, (Ø*St) represents the returns to schooling schedule. Taking the formula, developed by Hall and Jones (1999), to calculate the returns to schooling (Ø*St) and the human capital per worker (h):Ø*St = 0.134*St, **if St ≤ 4;** Ø*St = 0.134*4+ 0.101*(St-4), **if 4 < St ≤ 8;** Ø*St = 0.134*4+ 0.101*4 + 0.068*(St-8), **if 8 < St.** Thus: ht = exp (Ø*St).

[5]The "initial" capital Stock and following levels of capital stock are calculated using the common formula of perpetual inventory Method: Initial Stock: $K_0 = \frac{I_0}{g+\delta}$ Where: K0 is "initial" capital stock; I0 is "initial" investment level; g is geometric average growth rate of the first decade of investment; δ is depreciation rate of physical capital stock. Following levels of capital Stock: $K_{t+1} = I_t + (1-\delta)K_t$ (Law Motion of capital Stock) (Berlemann and Wesselhöft 2012).

[6] For more measures of trade openness, please see David (2007), "A guide to measure trade openness and policy".

markets, seen as a good way to capture both tariff and non-tariffs barriers, thus, countries with high price levels would be seen as countries with high protectionism level; and (iii) tariff measures which consist in simple tariff averages, trade-weighted tariff averages, revenues from duties as a percentage of total trade and the effective rate of protection (ERP).

c) Control variables

The control variables are used in the model to contain the simple impact of trade openness on total factor productivity, as in reality, total factor productivity may react to different variables rather than just trade openness. Thus, to avoid thinking that the study's results are created by omitting variables and to be more realistic this model incorporate six (6) control variables, namely: human capital, industrial development, financial development, government expenditure, foreign direct investment and Household consumption. All variables were attained from *World Bank Database.*

First, related with human capital, proxy used for human capital was average years of schooling, according to literature, high values of human capital represent a country's capacity to absorb knowledge, which positively affects total factor productivity, implying that a country with high average years of schooling, has a better capacity of absorption of knowledge which can come externally through trade openness, financial openness and/or produced inwards borders (Nelson and Phelps 1966), as well as guarantee the engender of domestic technology (Romer 1990a, 1990b; Aghion and Howitt 1998). Moreover, Miller and Upadhyay (2002) argued that effects of human capital in TFP growth differ at different levels of development, in low-income countries, human capital has a negative association with TFP growth, mean-while, for middle-income and high-income the association is expected to be positive. These results show that considering "all countries across economic development in the same way, in particular, in terms of policy prescriptions" is not the most accurate approach.

Second, Industrial development proxy consists in the percentage of industry value added in Gross Domestic Product. The industrial sector is seen as one of the channels to observe knowledge spillovers, thus industrial development (an increase in value added generate by increasing factors efficiency or through new technologies-technological progress) would dictate an increase in total factor productivity.

Third, the ratio of M2 (Money and *Quasi*-money) to GDP is used a proxy for financial development. The inclusion of this proxy comes with the fact that with a developed financial market, firms will have access to loans and can efficiently apply resources to projects with higher rate of return. Thus, financial development plays a relevant role as a contributor of TFP growth, as for Goldsmith (1969) by increasing marginal productivity of capital, as well as by promoting the efficient allocation of capital, ultimately, increasing saving rate (aggregate) and level of investment in domestic economy (McKinnon, 1973; Shaw, 1973).

Forth, ratio of government expenditure to GDP, as a proxy of government's expenditure on investment projects, assumes that increasing this ratio, meaning government's investments on productive projects such as physical infrastructures (roads, bridges, ports, airports, telecommunications, energy, economic zones, and so forth), as well as social infrastructures (schools, hospitals, and so forth), total factor productivity will tend to augment through time as infrastructure allows productive capacity development with increasing resources and enhancing private capital's productivity (Eisner 1986, Aschauer 1989 and Isaksson 2007). Even though public investment or public capital formation is morally good for society, economically it can generate crowding-out of private investment, due to lack of financial resources available for private sector through increasing interest rates in the economy (Isaksson 2007).

Fifth, in terms of FDI share of GDP, it is expected that with FDI inflows, the economy will be receiving not only financial resources but also new technologies and managerial advances. Thus, inflows of FDI would be related positively to total factor productivity (Alfaro et al. 2006).

Ultimately, with respect to Household consumption share of GDP, a high ratio would imply that less domestic resources are available for domestic private investors, which would affect negatively total factor productivity (Danquah et al. 2011).

3. 2. Methodology

Present study consists in a case study of Mozambique, the methodology used for this paper is as follows: (i) Bibliographic and documentary research, in order to collect information related to literature review and background on trade liberalization, total factor productivity and control variables; (ii) Quantitative data, primary and secondary data with the attempt to collect enough

information to develop the model and prove the main hypothesis; and (iii) Econometric approach focused on Time series Analysis was performed in order to develop the model based in reasonable assumptions and bring plausible conclusions and recommendations.

With regard to econometric approach and model building, conclusions were made based on results from Vector Error-Correction Model. Hence, following tests were used:

Stationarity and unit root tests: Dickey-Fuller tests and Quandt Likelihood Ratio Test for breaks

In time series analysis, the idea that past information about certain variables can be useful to discern historical relationship and thus, predict future, is explained by the stationary characteristic of some variables, which means that the probability of distribution does not change over time, but, if variables are non-stationary, meaning a change in the probability of distribution over time, it is not possible to rely on past information to predict the future. In presence of non-stationarity, forecast can be biased, inefficient or OLS regression statistical inferences (for instance, t-statistic and so forth) can be misleading (Stock and Watson 2007).

In this context, non-stationarity can be of two types: trends and/or breaks; while former is a persistent long term movement of a certain variable over time around its trend, latter is a distinct change or gradual evolution of coefficients over a long period of time. To prove for trend (stochastic and deterministic), graphic analysis and Dickey-Fuller tests were preceded, meanwhile, to prove for breaks, Quandt Likelihood Ratio statistic or Sup-Wald statistic.

In presence of trends, in particular, stochastic trends, it is usual that OLS t-statistic will follow a non-normal distribution, even when sample increases, thus confidence intervals are not valid and hypothesis tests can not be conducted. Furthermore, spurious regression problem, will lead to think that two or more time series seem to be related when indeed, they are not (Stock and Watson 2007).

On the other hand, if a sample has breaks, OLS regression considering entire sample will come up with a relationship which contains “average” results, as estimate will combine different periods, inducing to poor forecasts.

Optimal Lags and Co-integration test: Information Criteria and Johansen tests for co-integration

Lag values refer to past values of dependent, explanatory and control variables which contain important information to explain and/or predict future values of dependent variables. In this sense, choosing the lag order ρ demand an optimal balance between the marginal benefit of including more lags (more previous values of variables) and marginal cost of additional uncertainty in estimation (Stock and Watson 2007). Information criterion, such as Akaike Information Criterion (AIC), Schwarz-Bayesian (SBIC) and Hannah-Quinn (HQIC) as well as Likelihood Ratio test were used to choose optimal lag.

With respect to Co-integration, two or more variables are considered co-integrated when they present a common trend, which means that two or more time series variables with stochastic trends can move together in the long-run that they can seem to have common trend. Thus, to check for co-integration, Johansen test was implemented, which ended up approving the existence a common trend among variables considered in present study, thus, the use of VECM (Vector Error-correction model) was preferred for this study of time series analysis.

Vector Error-Correction Model (VECM)

The VECM model allows removing stochastic trend on non-stationary time series variables that are co-integrated (existence of common trend and possible long term relationship), by calculating the error correction term, $Yt-\theta Xit$, where θ is chosen to eliminate the common trend from the difference. VECM is then computed as a list of equations showing the multiple relationships among variables involved. As VECM is only appropriate for variables which show to be co-integrated, it allows assessing the short run properties of such variables; and a negative and statically significant error correction term will suggest that any short-term relationship between dependent and independent variables will enhance a stable long-term relationship between variables. If series are not co-integrated, VECM is not needed and Granger-Causality tests can be fulfilled.

Granger Causality tests

Granger causality refers to Granger predictability, which means that if a certain variable X (explanatory/independent) Granger-causes Y (dependent), then X is helpful to predict Y, considering other variables explicit in the regression. Granger causality can be preceded by using F-statistic on OLS coefficients under Null hypothesis that regressors have no predictive content for Y; as well as Granger Causality Wald test. Granger causality tests are used, among other reasons, to reinforce results from Vector-error correction model which considers co-integration among variables.

Time Series Regression Model Assumptions (from Stock and Watson 2007)

(i) $E(u_t|X_{it})=0$; Ut has a conditional mean zero.

(ii) Stationary distribution; $(X_{1i}, X_{2i}, \ldots, X_{ki}, Y_i)$, i=1,…,n, and Y_t and X_{it} become independent as j gets large (weak dependence), meaning, they are independently and identically distributed (i.i.d).

For non-stationary variables, forecast can be biased an inefficient (there can be alternative forecasts based on the same data with lower variance) or conventional OLS-based statistical inferences can be misleading.

(iii) Y_t and X_{it} are nonzero, finite fourth moments;

(iv) There is no perfect multi-colinearity.

3.2.1. Econometric Model: Vector Error-Correction Model (VECM)

This study is focused on time-series analysis, with a sample of 31 years per each variable denominated, from 1980 to 2010. Due to the fact that variables used presented unit root, meaning that they are non-stationary variables and they proved to be co-integrated, the usage of VECM was preferred to prove for long-term relationship of the variables.

The main attempt of this study is to evaluate the relationship (existent or not) between trade liberalization/openness and total factor productivity (TFP), as one of the mechanism that affects ultimately Gross Domestic Product (GDP) growth rate.

In order to test such hypothesis that trade liberalization exercise a positive impact on total factor productivity, the parameters calculated are related to the Mozambique, in the period defined above:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_{n+1} C_{it} + \varepsilon_t \; ; \; n=1,2,\ldots,x; \; i=1,2,\ldots, n+1; \; t=1980, 1981,\ldots, 2010; \quad \textbf{(1)}$$

$$LogY_t = \beta_0 + \beta_1 LogX_t + \beta_{n+1} LogC_{it} + \varepsilon_t \; ; \; n=1,2,\ldots,x; \; i=1,2,\ldots, n+1; \; t=1980, 1981,\ldots, 2010; \quad \textbf{(2)}$$

Where:

Y= total factor productivity, for the period 1980-2010;

β_o= constant or intercept; β_1= coefficient for main explanatory variable (trade openness) and β_{n+1}=coefficient for control variables.

X_t= main explanatory variable (trade openness); and C_{it}=control variables (average years of schooling, industrial value added share of GDP, ratio of M2 to GDP, ratio of government expenditure to GDP, FDI share of GDP and household consumption share of GDP).

ε= represents the error term.

In equation (2), variables in model (1) are presented in logarithms. In economic time series, logarithms are computed for some reasons, namely: (i) to show the growth of particular series as linear rather than exponential; many economic series (for instance, GDP, and so forth), present exponential growth which in the long run may lead to a certain percentage growth per year on an average basis (Stock and Watson 2007); (ii) to have a standard deviation approximately constant, as some economic time series are almost proportional to its level, standard deviation represents the percentage of the level of series, thus logarithm of series will present a constant standard deviation, approximately (Stock and Watson 2007); (iii) additionally, log transformation deals with heteroskedasticity problems which occasionally can be patent in some samples (Stock and Watson 2007).

4. Empirical Results

4.1. Summary Statistics

Summary statistics of all variables in Descriptive Analysis, table 1, as well as correlation matrix.

Table 1: Summary Statistics, Correlation Matrix (Absolute and Logarithm)

Panel A: Summary Statistics

Variables	Observations	Mean	Standard Deviation	Minimum	Maximun
Total Factor Productivity (Index)	31	141.520	28.590	101.310	196.190
Trade Openness (% GDP)	31	51.952	19.700	14.326	85.579
Average Years Schooling	31	1.151	0.220	0.920	1.810
Industry Value Added (%GDP)	31	22.396	5.851	13.105	34.421
Monetary Mass (%GDP)	31	18.231	8.232	7.638	37.549
Government Expenses (%GDP)	31	11.460	2.842	6.331	20.772
FDI (%GDP)	31	2.916	3.244	0.003	10.748
Household Consumption (%GDP)	31	89.355	6.428	80.520	102.435

Panel B: Correlation Matrix (5% level of significance)

	Tfp	Top	YearsSchl	Ind	M2y	Gov_exp	FDIY	CY
Total factor productivity	1.000							
Trade openness	0.720***	1.000						
Human capital	0.788***	0.439**	1.000					
Ind. Value Added	0.595***	0.186	0.336*	1.000				
Monetary Mass (M2)	0.776***	0.817***	0.693***	0.084	1.000			
Gov. Expenses	-0.041	-0.270	0.304*	0.264	-0.285	1.000		
FDI	0.658***	0.615***	0.565***	0.116	0.853***	-0.292	1.000	
Consumption share	-0.586***	-0.383**	-0.528***	-0.316*	-0.647***	0.107	-0.516***	1.000

Note: 1%, 5% and 10% level of significance are represented by ***, ** and * respectively.

Panel C: Correlation Matrix with logarithmic variables (5% level of significance)

	LTfp	LTop	LYearsSchl	Lind	LM2y	LGov_exp	LFDIY	LCY
Log Total factor productivity	1.000							
Log Trade openness	0.682***	1.000						
Log Human capital	0.745***	0.291	1.000					
Log Ind. Value Added	0.652***	0.276	0.421**	1.000				
Log Monetary Mass (M2)	0.667***	0.770***	0.513***	0.054	1.000			
Log Gov. Expenses	-0.023	-0.263	0.376**	0.244	-0.380**	1.000		
Log FDI	0.406**	0.739***	0.182	-0.169	0.913***	-0.573***	1.000	
Log Consumption share	-0.588***	-0.292	-0.551***	-0.383**	-0.622***	0.154	-0.392**	1.000

Note: 1%, 5% and 10% level of significance are represented by ***, ** and * respectively.

The sample data consists in 31 years of observation for Mozambique, from 1980 to 2010. Being the dependent variable, total factor productivity, main explanatory variable, trade openness (which proxy is trade volume ratio), and control variables, human capital (average years of schooling), industrial development (industry value added share of GDP), financial development (ratio of M2 to GDP), government expenditure (ratio of GDP), FDI (share of GDP) and Household consumption (share of GDP).

Table 1, Panel B and C, show that trade openness and total factor productivity have a positive and statistically significant correlation at 1% significance level. Same results are seen for average years of schooling, industrial share of GDP, ratio of M2 to GDP and FDI to GDP ratio (significant at 1% and 5% level of significance), in relation to total factor productivity. However, government expenditure and consumption ratio denote negative correlation with total factor productivity, former its coefficient not being statistically and latter's being significant, at 1% level of significance.

4.2. Dickley-Fuller Test for unit roots

In regression analysis of time series data, information from the past can be used to quantify historical relationships in order to predict the future, in this sense, distribution of certain time series does not vary over time (the probability of distribution), hence variables are denominated stationary. Otherwise, if future contrasts with past, historical relationship may not be trustworthy; therefore, such time series variables are called non-stationary (Stock and Watson 2007).

The test for unit roots, Dickley-Fuller, assumes as Null Hypothesis that variables present unit roots, meaning that they are non-stationary, varying across time (*see table 2*). According to *Dickey-Fuller* test for unit roots, the variables transformed in logarithm are non-stationary at 1% and 5% level of significance.

Dickey-Fuller test are also useful to draw conclusion regarding the character of non-stationarity, meaning the existence of a stochastic trend. The character non-stationarity of the variables is related with trends or breaks, while former consists in a persistent long term movement of a variable over time, latter represents a change in the population regression function (coefficients change) over the course of the sample, such change can be discrete or gradual evolution over a long time period (please see *graph 1* for graphic visualization of variables trends).

4.3. Heteroskedasticity and Quandt Likelihood Ratio

Tests for Heteroskedasticity (Breusch-Pagan test) and for breaks in Total Factor Productivity sample (Quandt Likelihood Ratio statistic or Sup-Wad statistic) were produced.

a) Heteroskedasticity tests: Breusch-Pagan test

Heteroskedasticity, per se, is the lack of constant variance in the error term's conditional distribution given a certain variable Xi, in other words, if the variance of the conditional distribution does depend on Xi, otherwise, errors are considered homoskedastic. For the sample (1980-2010) of Mozambique economy for the variables' logarithms, LTfp, LTop, LYearsSchl, LInd, LM2y, LGov_exp, LFDIY and LCY, error terms were found to be homoskedastic as shown in *table 3,* by using the Breusch-Pagan/Cook-Weisberg tests for Heteroskedasticity.

b) Tests for Breaks in TFP (1980-2010): Quandt Likehood ratio (QLR) statistic or Sup-Wad statistic

The period chosen for this analysis 1980-2010, is represented historically, in Mozambique's economy, as a period of many structural changes, such as: (i) economic transformation with the transition from a socialist economy to a capitalist economy by joining the Bretton Woods institutions (International Monetary Fund and World Bank) in 1987 and following trade liberalization as well as restructuration plans (Economic Plan of Rehabilitation-EPR); (ii) social transformation (end of Civil War, Intra-cities migration, and so forth); (iii) political transformation (democratization process with first election process being held on 1994, and so forth) (Kanji et al. 2004).

Therefore, for these reasons, it was proceeded a test for breaks on Total Factor Productivity, using the Quandt Likelihood Ratio test, which is a variation of Chow test for breaks with the advantage of allowing to search for breaks without prior knowledge of the date and able to detect single discrete and/or multiple breaks and even slow evolution of the regression function. Quandt Likelihood ratio test suggested that Total factor productivity data registered break on following dates: 1987, 1988, 2000, 2004 and 2005 (see *table 4* and *graph 2).* For VECM analysis, dummy variables were created, namely: dummy1 for 1988 (all values before are equal to 0 and after are equal to 1), dummy 2 for 2000 (values before are equal to 0 and after are equal to 1) and dummy 3 for 2005 (all values before are equal to 0 and after are equal to 1).

4.4. Vector Error-correction model (VECM)

4.4.1. Johansen tests for co-integration

Before running VECM, it is necessary to find out if variables presented in this study are or not co-integrated: total factor productivity, trade openness, human capital, industry value added, monetary mass (M2), government expenses, foreign direct investment and consumption ratio.

Two or more variables are considered co-integrated when they have the same stochastic trend in common, moving closely together in the long-run (long-term relationship). To prove for co-integration[7] it was used the *Johansen tests* for co-integration, which consist of two tests, Maximum Eigen-value test and trace statistic test. While Maximum Eigen-value test assumes the null hypothesis of *r* (r=0, 1, 2,…, n-1) co-integrating relations against an alternative hypothesis of r+1 co-integrating relations; the trace statistic test's null hypothesis is that there are *r* co-integrating relations against the alternative of *n* (number of variables in the model) co-integrating relations. If the results between Trace statistic and Eigen-value differ, result from trace statistic is therefore preferred. In this case, trace test rejected the null hypothesis of r=0 up to r=5, when the rank equals 6 (Ho: r=6), the null hypothesis is not rejected at the 5% level of significance (8.2503<15.41), meaning, trace statistic does not find evidence to reject the null hypothesis that the 8 variables in this model are co-integrated, as rank is equal to 6, greater than zero and less than 8 (the number of variables), showing that these time series variables are co-integrated among themselves (*see table 5*). For visual perception of how co-integrated variables are, please *see graph 3.*

4.4.2. Optimal Lag selection

The optimal number of lags is needed to be used in VECM method. Lag selection (ρ) is related with the number of past-values of the variables contained in the model which will be used to predict or forecast the future or adjust the model. The optimal lag (ρ*) requires balance between the marginal benefit of including more lags against the marginal cost of additional estimation uncertainty, thus, too low lag order would omit, probably, important information existent in more

[7] There are three ways to prove that two or more variables are co-integrated, first is using economic theory and knowledge; second, graph the variables to examine whether there is or not a common stochastic trend; and third, performing statistical test for co-integration such as Engle-Granger Augmented Dickey-Fuller test or EG-ADF test (Stock and Watson 2007).

distant lagged values, meanwhile, very high lag order would introduce additional estimation error into forecasts (Stock and Watson 2007). The information criterion is one of the methods used to test for optimal lags, it can be: AIC (Akaike information criterion), Schwarz-Bayesian information criterion (SBIC) and HQIC (Hannan-Quinn Information Criterion); as well as the Likelihood Ratio tests. The information criterion trades of the sum of squared residuals- SSR (when a lag is added this term decreases) and the number of estimated regression coefficients (the number of lags ρ, plus the intercept, which increases the term). The optimal lag order, ρ, will be the one that minimizes the information criterion. For this study, the optimal lag is 2 by using the Likelihood ratio test (*see Table 6*).

4.4.3. Vector Error-correction Model

The time series variables incorporated in present study were shown to be co-integrated, which suggests a long term-relationship, and the optimal number of lags obtained was 2.

The Vector Error-Correction Model is used to eliminate the unit root of variables (eliminate the stochastic trend) which are co-integrated. Hence, if two or more variables are co-integrated, one way to eliminate the common trend and induce stationarity is to compute $(Yt-\theta Xt)$, the error correction term, where θ is chosen to expunge the common trend from the difference. This model is a set of *k* time series regressions, in which the regressors are lagged values of all *k* series thus, there will be a list or "vector" of time series variables. In practice, the error correction term can help to forecast dependent variables, explanatory variables and even other variables possible related with the model. If variables which are not co-integrated are modeling using VECM, the error term will present unit root, I(1), introducing a trend which can result in poor out-of-sample forecast performance, this is the reason why VECM must be used with a combination of economic theory on behalf of co-integration and empirical analysis (graphs and statistical tests)[8].

a) Long-term relationship

[8] Stock and Watson, "Additional topics in time series regression", in *Introduction to Econometrics* (Boston: Pearson Education, 2007).

Results of VECM are shown in Table 7. There were generated 8 co-integrated equations. The final co-integrated equation for total factor productivity as dependent variable, trade openness as explanatory variable and control variables, human capital, industrial development, financial development, government expenses, foreign direct investment and household consumption ratio, shows a statistically significant long-term relationship as the error-term, θ, is negative and significant at 5% level of significance. Trade openness its coefficient was found to be positive and statistically significant at 1% level of significance, as well as coefficients for average years of schooling, government expenses ratio of GDP, foreign direct investment to GDP; mean while, coefficients for industry, M2 and household consumption ratios to GDP were seen to be negative and statistically significant at 1% level of significance. Because regressions were done using logarithms, coefficients' interpretation should be long-run elasticities, thus, if trade openness increase in 1% it is likely that total factor productivity will also augment in 0.107%.

b) VECM including interaction term of trade openness and human capital

The analysis was extended to include an interaction term of trade openness and human capital (trade openness measure, percentage of trade volume to GDP, and human capital measure, average years of schooling).

Some studies related with total factor productivity have introduced an interaction term in order to assess the impact of trade openness conditioned by human capital levels on TFP, as well as the impact of human capital on TFP conditioned by levels of trade openness. For instance, Miller and Upadhyay (2000; 2002), argue that the interaction term between trade openness and human capital had a significant effect on TFP growth. For these authors, human capital alone, was not able to justify changes in TFP, meanwhile, trade openness produced a positive effect, using a panel data (sample of 83 countries, from 1960 to 1989). However, when including interaction term, trade openness its coefficients were statistically significant, being positive for high income countries and negative for low-income countries; and human capital was considered a threshold variable, as interaction term its coefficients were positive for low-income (low human capital levels) countries and negative for high-income countries (high levels of human capital) .

Moreover, Bassetti (2007) also argued that the interaction term had a significant effect on TFP, denoting that impact of human capital and trade openness on TFP growth will be subject to the levels of both variables in a certain country, suggesting a non-linear relationship between trade openness, human capital and total factor productivity. Findings from this study suggested that for countries above a certain level of human capital (human capital as a threshold variable) will benefit more trade openness, in relation to TFP growth, than countries below a certain threshold of human capital, impacting negatively on total factor productivity, additionally, a threshold was found for trade openness.

Hence, countries were divided in four (4) quadrants: (i) first, countries with high levels of human capital and trade openness, would have more gains in TFP growth by using the stock of human capital to adopt new technologies from abroad and catch up with technology leader; (ii) second, countries with low human capital and high level of trade openness, would have losses of TFP (negative growth of TFP), as international competition would be to harsh on domestic economy due to lack of human capital endowment; (iii) third, countries with low levels of human capital and trade openness, are in better position than previous as there are not so exposed to international competition, total factor productivity growth still negative, and to catch up with technology leaders they must achieve a certain level of human capital and trade openness; (iv) forth, countries with high human capital level and low trade openness level, have enough absorption capacity in terms of human capital to benefit from more trade openness (Bassetti 2007).

Nevertheless, Harrison (1996) found that interaction between trade and human capital rarely brought significant results, when using a sample of 51 countries from 1960 to 1987.

In present study, the error term, θ, remains negative and significant at 5% level significance which denotes a stable long-term relationship among total factor productivity, trade openness, human capital, industrial development, financial development, government expenses, foreign direct investment and household consumption ratio and interaction term between trade openness and human capital, compared with VECM without interaction term (*see table 8).*

All coefficients results from this VECM regression are similar to previous VECM which does not include interaction term of trade openness and human capital, except for trade openness

which coefficient was found to be negative and significant at 1% level of significance contrary to the positive and significant coefficient found in VECM without interaction term. In fact, with the inclusion of interaction term, trade openness coefficient will include its dependence upon levels of human capital; in this sense, entire trade openness impact on total factor productivity will be indeed, measured by the sum of trade liberalization coefficient and the product between values of human capital (generally, the average value of human capital is used) and the coefficient of interaction term; same principle is also applicable for human capital coefficient.

This result would suggest that conditioned by the existence of low level of human capital, trade openness exerted a negative impact on total factor productivity levels in Mozambique, during period in analysis, corroborating with results by Miller and Upadhyay (2000) and Harrison (1996). Additionally, the interaction term its coefficient is negative and statistically significant at 1% level of significance.

This result for Mozambique is explained by Bassetti (2007), where the author considered a non-linear relationship between trade openness, human capital and total factor productivity, assuming that impact of trade openness and human capital in TFP will be defined by thresholds of human capital and trade openness, respectively. Hence, for countries with high level of trade openness and low level human capital would experience severe reduction in total factor productivity due to strong international competition faced with insufficient human capital to absorb technologies from abroad. In this sense, policies toward human capital investment should be stimulated rather than trade liberalization, in the case of Mozambique.

c) VECM including binary variables for breaks (1988, 2000 and 2005)

As showed above, when performing the Quandt Likelihood ratio statistic, sample presented five (5) break dates, namely, 1987, 1988, 2000, 2004 and 2005. Grouping breaks in three (3) dates, binary variables were created and integrated in VECM regression, namely, dummy 1 for 1988 break date, dummy 2 for 2000 break date and dummy 3 for 2005 break date.

Results for VECM including binary variables for breaks compared with original VECM results (without break dummies and without interaction variable) were as following: (i) for trade openness, its coefficient is, similarly, positive and statistically significant at 1% level of significance; (ii) for control variables, coefficients were found to be statistically significant at 1%

level; coefficient for government expenses was negative (opposed to positive sign with original VECM); while remaining variables preserved same signal, including human capital, which coefficient interpretation include both individual and trade liberalization joint effect on productivity.

The error correction term for VECM including binary variables is negative and statistically significant at 10% level of significance, implying again a long term stable relationship between variables in the model.

d) VECM including interaction variable and binary variables for breaks (1988, 2000 and 2005)

A VECM which includes interaction term between trade openness and human capital, and binary variables for breaks comparing with original VECM, produced following results: (i) trade openness coefficient is negative and statistically significant at 1% level, compared to positive and statistically significant coefficient from original VECM (without interaction term and break dummies variables). According to what was described above, with the inclusion of interaction term, trade openness coefficient will contain not only its individual impact on productivity but also its impact dependent upon levels of human capital, hence, total impact from trade openness will consist on the sum of the coefficient for trade liberalization and the product of values of human capital (generally, average value of human capital is used) and the coefficient of interaction term; (ii) coefficients for financial development (M2), government expenses and FDI have opposed signs to original VECM, now Monetary Mass (financial development) is impacting positively on total factor productivity, and government expenses are affecting negatively total factor productivity as well as FDI, all coefficients are significant at 1% level of significance; (iii) remaining variables, human capital, industry value added and consumption share preserve same sign, meaning that human capital is impacting positively on total factor productivity (human capital its overall coefficient include both individual and trade liberalization joint effect on productivity), while industry value added and consumption ratio affect negatively TFP, coefficients are significant at 1% level; (iv) interaction term coefficient remains statistically significant (1% level of significance) and negative.

Regarding, the error correction term for VECM including interaction variable and binary variables, it was observed to be negative but not statistically significant, implying that no long term stable relationship between variables is evident in this particular model.

With respect to hypothesis developed previously, evidence for Mozambique shows that:
(i) The impact of trade openness in total factor productivity is rather ambiguous, as when excluding an interaction term its effect is positive, meanwhile, when including only interaction term of trade openness and human capital as well as when including both interaction term and break dummies, its effect is negative, being results statistically significant at 1 % level;

(ii) Human capital impact on TFP was seen to be positive and statistically significant at 1% level of significance, in both cases, including and excluding interaction term as well as when including binary variables, thus not rejecting the hypothesis of positive impact;

(iii) The role of industrial development in total factor productivity was negative and significant at 1% level, when including and excluding interaction term as well as when including binary variables, not rejecting null hypothesis of negative impact, and possible explained by low level of Mozambique industrial development (average percentage of Industry Value Added to GDP is 22,4%); with the destruction of most productive infrastructures such as bridges, plants, telecommunications and so forth, during the Civil War (1976-1992), total factor productivity was seriously affected, and only after this war, efforts to raise domestic industry start taking place. Hence, in average, for the period in analysis (1980-2010) it is expected that industrial's lack of development hampered total factor productivity growth as TFP needs a "platform" to grow from, and factor accumulation must come before innovation (TFP improvement) such as argued by Barros and Sala-i-Martin (2004).

(iv) The impact of financial sector on TFP was deemed to be negative and significant at 1% level of significance, when including and excluding interaction term as well as when including only binary variables, thus not rejecting the hypothesis of negative impact presumed for the case of Mozambique, however when including both binary variables and interaction term, coefficient becomes positive and statistically significant (1% level), leaving conclusion ambiguous; during the period in analysis (1980-2010), the experience of unregulated financial sector liberalization

and government bailout might be accounted for the negative relationship between level of financial development and productivity growth, as argued by Rioja and Valen (2004).

(v) Coefficient for government expenditure was found to be positive and statistically significant, denoting a positive effect on TFP when excluding and including interaction term, not rejecting null hypothesis of positive impact, albeit, when including only binary variables and both break dummies and interaction term, government expenses coefficients were negative and significant at 1% level, leaving conclusion ambiguous;

(vi) The impact of FDI on TFP was statistically significant and positive, rejecting null hypothesis of negative impact, at 1% level of significance, when including and excluding interaction term and also break dummies variables, meanwhile, when including both break dummies and interaction term, government expenses coefficients were negative and significant at 1% level, leaving conclusion ambiguous; such results for Mozambique may be due to FDI its ability to increase capital formation, complementing Government efforts to increase productive capacity even though knowledge spill-overs may not be observed as vertical and horizontal linkages between foreign companies and domestic firms are weak and human capital's ability to absorb knowledge is low;

(vii) Lately, consumption ratio to GDP was found to negatively impact on TFP, according to literature, not rejecting null hypothesis of negative impact, at 1% level of significance, when excluding and including interaction term of trade openness and human capital as well as when including binary variables and both break dummies.

It is important to stress that results from Vector Error-correction model are preferred over OLS regression, as OLS regression does not eliminate unit root patent in present time series sample, which was removed when adopting VECM, and further usage would lead to wrong statistical inferences as estimators become biased and inefficient, therefore, VECM results presented should be preferred over OLS regression.

4.5. Additional test

a) Granger Causality Tests (tests of predictive content)

Granger Causality Test refers to tests which examine the Null hypothesis that the coefficients on all values of independent variables are equal to zero. Causality, in this sense, considers that certain variable X Granger-causes Y, thus X is a useful predictor of Y, considering other variables in the regression- Granger predictability or Granger causality (Stock and Watson 2007). It means that past values of trade openness contain reliable information to be used in forecasting changes in the total factor productivity, beyond information contained in lagged values of total factor productivity (Stock and Watson 2007).

To prove for Granger-Predictability, Granger causality Wald tests was run. First equation assumes total factor productivity as dependent variable, trade openness as explanatory variable and control variables, human capital, industrial development, financial development, government expenses, FDI and consumption ratio. The Granger Causality Wald tests, which considers the Null Hypothesis that there is no Granger-causality of trade openness in total factor productivity and vice-versa, was not rejected, at a 5% level of significance (*see table 9*). In this sense, individual tests showed that Trade openness was not a good predictor of total factor productivity and vice-versa, the results are extended for control variables, except for government expenses which was found to be a good predictor for total factor productivity, individually.

On the other hand, the line with respect to ‘all’, test the null hypothesis that coefficients of the two lags of all variables (trade openness and control variables) do not Granger-cause total factor productivity, meaning that these coefficients are jointly equal to zero (0). The result for this test rejected the null hypothesis at 1% level of significance, which implies that jointly, trade openness and control variables can be considered good predictors of TFP.

These results, particularly from individual tests, reinforce the argument of co-integration of total factor productivity, trade openness and control variables, that these variables maintain a stable long-term relationship throughout period in analysis, rather than the argument of Granger-causality going from trade openness and control variables to total factor productivity.

5. Conclusions and Recommendations

Conclusion

The main hypothesis of the present study is that trade liberalization had a positive impact on total factor productivity performance in Mozambique during the period 1980-2010. By using Vector Error Correction Model, results failed to reject main hypothesis, but when including an interaction term between trade openness and human capital (trade openness its impact on TFP is conditioned by human capital levels and vice-versa) as well as when including both interaction term and break dummy variables (considering structural change), trade openness was deemed to affect negatively total factor productivity, rejecting then the main hypothesis; moreover, it was possible to find that there is a long-term stable relationship between total factor productivity and trade openness and control variables, human capital, industrial development, financial sector development, government expenses, foreign direct investment and household consumption ratio even when interaction term is added. Hence, this study showed the importance of a time-series analysis by employing a Vector Error-correction Model for the case of Mozambique.

With respect to further hypothesis developed in present study, evidence for Mozambique shows that:
(i) The impact of trade openness in total factor productivity is rather ambiguous, as when excluding an interaction term its effect is positive, meanwhile, when including only interaction term of trade openness and human capital as well as when including both interaction term and break dummies, its effect is negative, being results statistically significant at 1 % level;

(ii) Human capital impact on TFP was seen to be positive and statistically significant at 1% level of significance, in both cases, including and excluding interaction term as well as when including binary variables, thus not rejecting the hypothesis of positive impact;

(iii) The role of industrial development in total factor productivity was negative and significant at 1% level, when including and excluding interaction term as well as when including binary variables, not rejecting null hypothesis of negative impact, and possible explained by low level of Mozambique industrial development (average percentage of Industry Value Added to GDP is 22,4%); with the destruction of most productive infrastructures such as bridges, plants,

telecommunications and so forth, during the Civil War (1976-1992), total factor productivity was seriously affected, and only after this war, efforts to raise domestic industry start taking place. Hence, in average, for the period in analysis (1980-2010) it is expected that industrial's lack of development hampered total factor productivity growth as TFP needs a "platform" to grow from, and factor accumulation must come before innovation (TFP improvement) such as argued by Barros and Sala-i-Martin (2004).

(iv) The impact of financial sector on TFP was deemed to be negative and significant at 1% level of significance, when including and excluding interaction term as well as when including only binary variables, thus not rejecting the hypothesis of negative impact presumed for the case of Mozambique, however when including both binary variables and interaction term, coefficient becomes positive and statistically significant (1% level), leaving conclusion ambiguous; during the period in analysis (1980-2010), the experience of unregulated financial sector liberalization and government bailout might be accounted for the negative relationship between level of financial development and productivity growth, as argued by Rioja and Valen (2004).

(v) Coefficient for government expenditure was found to be positive and statistically significant, denoting a positive effect on TFP when excluding and including interaction term, not rejecting null hypothesis of positive impact, albeit, when including only binary variables and both break dummies and interaction term, government expenses coefficients were negative and significant at 1% level, leaving conclusion ambiguous;

(vi) The impact of FDI on TFP was statistically significant and positive, rejecting null hypothesis of negative impact, at 1% level of significance, when including and excluding interaction term and also break dummies variables, meanwhile, when including both break dummies and interaction term, government expenses coefficients were negative and significant at 1% level, leaving conclusion ambiguous; such results for Mozambique may be due to FDI its ability to increase capital formation, complementing Government efforts to increase productive capacity even though knowledge spill-overs may not be observed as vertical and horizontal linkages between foreign companies and domestic firms are weak and human capital's ability to absorb knowledge is low;

(vii) Lately, consumption ratio to GDP was found to negatively impact on TFP, according to literature, not rejecting null hypothesis of negative impact, at 1% level of significance, when excluding and including interaction term of trade openness and human capital as well as when including binary variables and both break dummies.

It is important to stress that results from Vector Error-correction model are preferred over OLS regression, as OLS regression does not eliminate unit root patent in present time series sample, which was removed when adopting VECM, and further usage would lead to wrong statistical inferences as estimators become biased and inefficient, therefore, VECM results presented should be preferred over OLS regression.

With respect to interaction term between trade openness and human capital, its coefficients are negative and statistically significant at 1% level of significance for VECM including interaction term and VECM including both interaction term and binary variables for breaks. This would suggest that conditioned by low level of Mozambican human capital, trade openness exerted a negative impact on total
\ factor productivity levels in Mozambique, during period in analysis, same can be concluded for human capital, that levels of trade openness conditioned impact of human capital on total factor productivity, corroborating with results by Miller and Upadhyay (2000), Harrison (1996), Bassetti (2007). These authors argue that relationship between trade openness, human capital and total factor productivity is non-linear suggesting that thresholds for human capital and trade openness should be incorporated; therefore, impact of both variables in TFP will depend on such thresholds. For the case of Mozambique, with high levels of trade openness (average of 52% of trade volume to GDP) and low level of human capital (average of 1.2 years of schooling), the impact on total factor productivity will be negative (denoted by negative coefficient for interaction term between trade openness and human capital) as a result of low absorption capacity and inability to deal with strong international competition.

Future studies should focus on calculating thresholds for human capital and trade openness, for the case of Mozambique, and assuming a non-linear relationship between trade openness, human capital and total factor productivity.

Moreover, this paper produced Granger-Causality Walds tests which showed that individually, variables in the study are not able to predict total factor productivity, even though, joint test shows that trade openness and control variables could be considered good predictors of total factor productivity, jointly. Individual results reinforce, indeed, the argument of co-integration of total factor productivity, trade openness and control variables, rather than argument of Granger-causality going from trade openness and control variables to total factor productivity.

Policies regarding any of the variables presented in this study should consider their long term relationship in order to influence positively total factor productivity growth and ultimately, economic growth, in Mozambique. For instance, policies regarding human capital (education, technical formation, vocational centers, R&D), saving rate (attractive interest rates, financial intermediation expansion, population education), government expenditure (productive investments, infrastructure investments), and so forth.

Recommendations

Policies recommendations

Trade liberalization its positive effects on total factor productivity in Mozambique, may depend on its connections and interactions with control variables cited above, and searching for ways to capitalize positive effects of trade openness may be through fostering for instance, human capital, financial development, industry growth, government expenditure towards “core” and social infrastructures and saving rates.

For instance, Njikam et.al (2006) found that for Sub-Saharan Africa (SSA), trade openness results in a increase of TFP in Sub-Saharan African (SSA) region only if issues related to supply conditions such as poor transport and communication infrastructure, unstable supply of energy, bad governance, low human capital formation, physical capital accumulation, underdeveloped financial sector, are adequately treated; furthermore, population growth was found to affect positively TFP in some SSA countries and negatively in other SSA countries.

The interaction term between trade openness and human capital shows how trade openness its effect on total factor productivity is depending on the levels of human capital. According to Bassetti (2007), an economy with high stock of human capital would be able to reap more benefits from trade liberalization policies, than countries with low levels of human capital who would eventually, suffer from trade liberalization due to international competition. Thereupon, policies regarding investment in human capital (education and health), in order to improve absorptive capacity should be adopted and each country its government should be aware of country its specific situation when implementing trade openness policies.

For the case of Mozambique, levels of average years of schooling are relatively low, being the average 1.81 years compared to Sub-Saharan Africa (2.71 years) and world levels (5.88 years) (Barro-Lee database). As a proxy for human capital, this represents also low level of absorption capacity of knowledge by the economy, and policies towards education (primary, secondary and tertiary), technical formation, vocational centers, Research and Development, and so forth, should be considerate in order to improve the characteristics of the human capital (greater levels of education, reduced level of illiteracy, increased ability to absorb technology).

For developing countries such as Mozambique, reducing technological knowledge gap in order to catch up technological leaders (such as United States) can only be done through adequate absorption of new technologies and it ought to be molded to country-specifications in order to be effectively used. In this sense, as for Nelson and Phelps (1966), Romer (1990b), Aghion and Howitt (1998), Isaksson (2001), Isaksson (2007), investments in education and R&D should be a priority rather than innovation and knowledge transfer which should be left in charge of technological leaders.

With respect to household consumption ratio, the mean for Mozambique is 89.35 % of GDP, which indicates a high level of consumption and consequently, low levels of saving rate. In the long-term this tendency could represent a lack of domestic resources to boost domestic private investment, possibly, increase competition between public investment and private investment over limited capital (crowding out effect). Thus, policies which incite savings through education of the population about benefits of savings, attractive interest rates, expansion of financial intermediation to remote zones of the country, and so forth, can serve as good ways to stimulate savings and contribute to total factor productivity (and multiply trade openness effects).

Regarding, government expenses, the existence of physical ("core" infrastructures such as roads, highways, airports, water systems, sewers) and social infrastructures (health and education system) affect positively total factor productivity (Aschauer 1989). Thus, a state that provides good infrastructures and services guarantees a platform for development of private sector projects (domestic and foreign), for example, exports led-industries would benefit from increasing levels of trade openness by accessing international market, increased competition and economies of scale, if there is proper transportation system (roads, airports, ports), telecommunications which reduce transaction costs and enhance productivity; and import-led companies would also benefit from trade openness by having access to wider range of inputs, reduced tariffs and so forth (Eisner 1986, Aschauer 1989 and Isaksson 2007).

In this sense, it is possible to say that due to the co-integrated relationship between total factor productivity, trade openness and control variables, it is not expected to treat each variable solely through time but yet policies regarding any of them should consider their long term relationship in order to influence positively total factor productivity growth and ultimately, economic growth, in Mozambique. These are, indeed, the contributions of present study in terms of economic policies.

Future studies recommendations

First, concerning model limitations, present study used a measure of total factor productivity based on Cobb-Douglas production function, which assumes perfect competition, additionally, limitations arise from: inputs measurement (capital and labor), missing or inappropriate data, theory specifications and aggregate production function assumptions. Hulten (2001) argued that TFP was indeed a "measure of our ignorance" as it represents the "left-over" factor. Other measurements of TFP were developed such as Data Envelopment Analysis (DEA) approach proposed by Färe et al. (1994) which assumes the existence of inefficient behavior and provides a production frontier that represents the maximum achievable level of production; furthermore, DEA approach is able to decompose TFP growth into its components: technological progress (innovation) and technical efficiency (i.e. technological adoption by input factors). Therefore, future studies incorporating a much "clean" measure of TFP is required, as well as robustness tests to confirm results with other measures of control variables.

Second, problems of endogeneity, omitted variables, non-stationary, and reverse causality, may be solved in future studies by using other estimation techniques such as Generalized Method of Moments System (GMM), Fully Modified Ordinary Least Square, Panel Co-integration Models and so forth. The Vector Error-Correction Model used in present study successfully deals with data that is co-integrated, endogenous and non-stationary only (Stock and Watson 2007, Asari 2011), not being able to suppress omitted variables and reverse causality problems.

Third, as TFP showed an ambiguous relationship with total factor productivity during the period analyzed, there still room to specifically define the mechanism through which trade openness has been influencing productivity growth and consequently, economic growth in Mozambique. It is argued that with trade openness, local firms are exposed to international competition, which forces the exit of less efficient firms, and entrance and predominance of more efficient firms. This also benefits the local market consumers that have a wider variety of products to purchase. Furthermore, with trade openness, foreign direct investment might follow free markets, allowing not only the increase of available capital but also provides the transfer of technology to local firms (Isaksson 2007). However, in face of such benefits, a country might still face many constrains (political, economic, social, and judicial environment), which draw back trade openness possible benefits. Hence, for the case of Mozambique, the channels through which trade openness affects total productivity still open for discussion and in need of further research.

Fourth, many studies are specific to trade openness its impact on total factor productivity at different levels as industry (Rajan and Zingales 1998, Haidar 2012), manufacturing (Hwang and Wang 2004, Lisboa *et al* 2010, Nataraj 2011), agriculture (Hong et al. 2010, Teweldemedhin and Van Schalkwyk 2010) and so forth, rather than aggregate total factor productivity, being possible to detect and clarify how trade openness affected total factor productivity at different levels, benefiting decision-making regarding policies (agriculture, industry, finance, and so forth), thus, for the case of Mozambique, this type of approach should be further explored.

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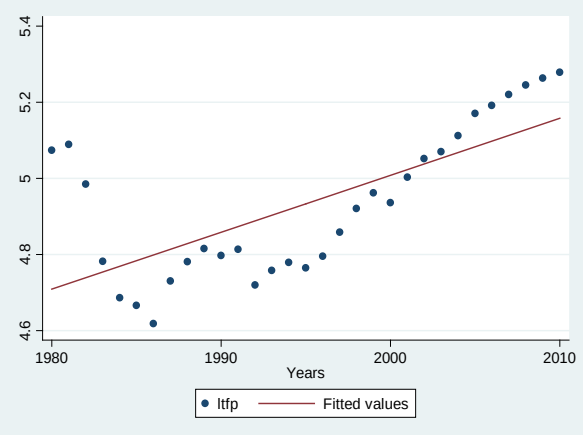
Annexes

Table 2: Dickey-Fuller tests for unit root

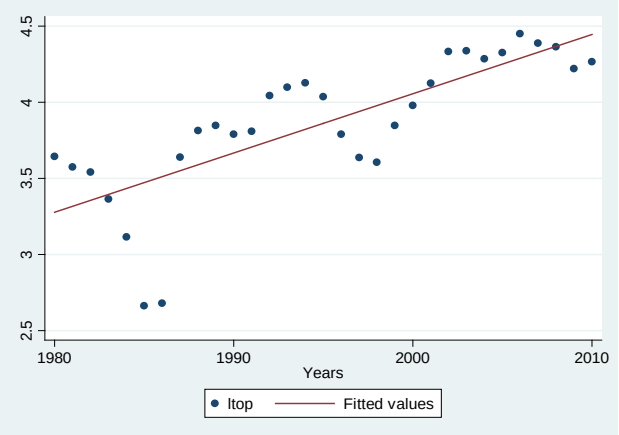
Dickey_Fuller test Unit roots Lag (1)	Total factor productivity	Trade openness	Human capital	Ind. Value Added	Monetary Mass (M2)	Gov. Expenses	FDI	Consump-tion share
t-test statistics	-0.102	-1.277	4.041	-2.207	-0.029	-1.882	-2.101	-2.113
1% critical value	-3.716	-3.716	-3.716	-3.716	-3.716	-3.716	-3.716	-3.716
5% critical value	-2.986	-2.986	-2.986	-2.986	-2.986	-2.986	-2.986	-2.986
Mackinnon p-value for Z(t)	0.9493	0.6396	1.0000	0.2038	0.9561	0.3408	0.2440	0.2393

Graph 1: Non-stationarity, stochastic trends for TFP, TOP, YearsSchl, M2y, Ind, Gov_exp, FDIY and CY.

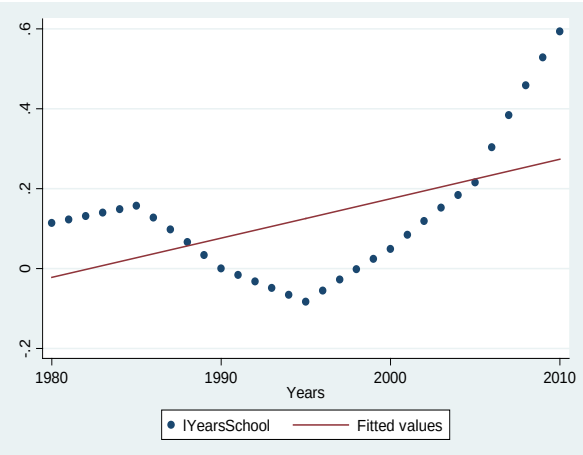
(i) Trend: Total factor productivity (Log)



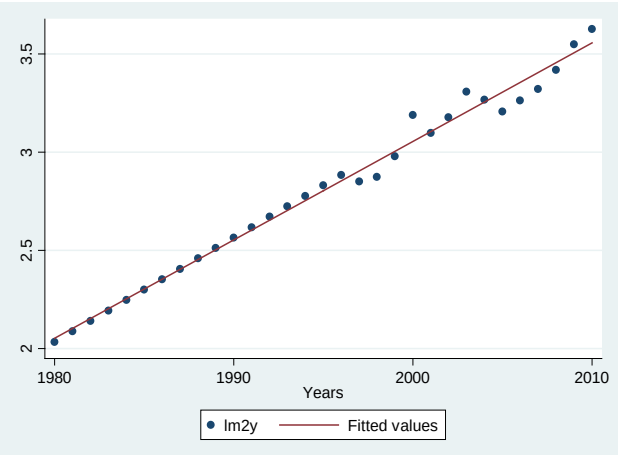
(ii)Trend: Trade openness (Log)



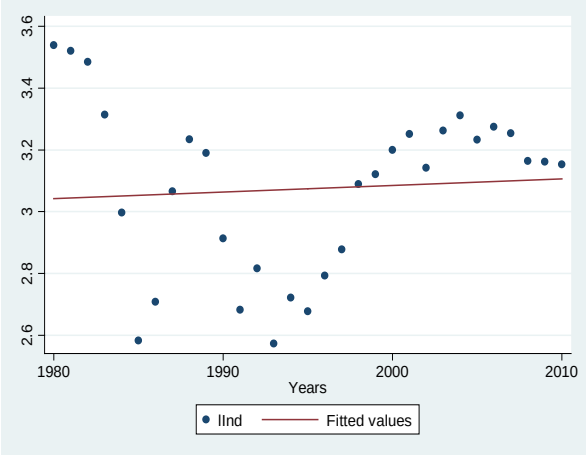
(iii) Trend: Average Years of Schooling (Log)



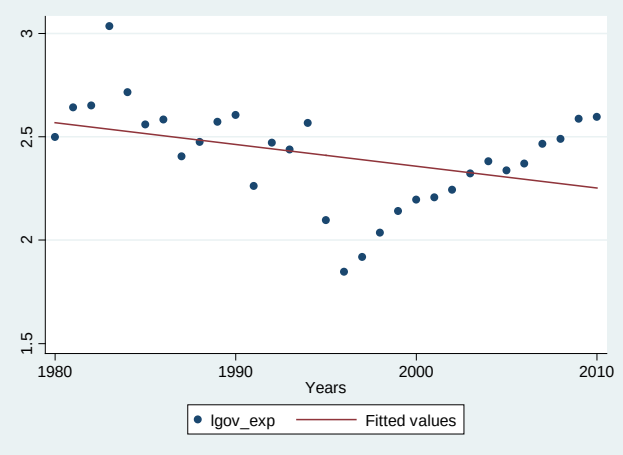
(iv) Trend: Monetary Mass (M2) to GDP (Log)



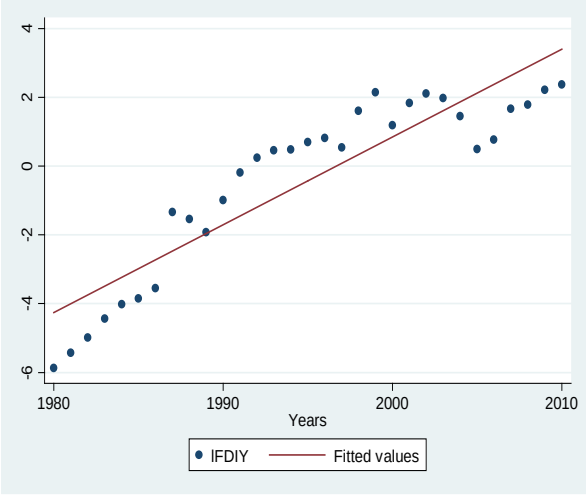
(v) Trend: Industry value added to GDP (Log)



(vi) Trend: Government expenses to GDP (Log)



(vii) Trend: Foreign direct investment to GDP (Log)



(viii) Trend: Consumption to GDP (Log)

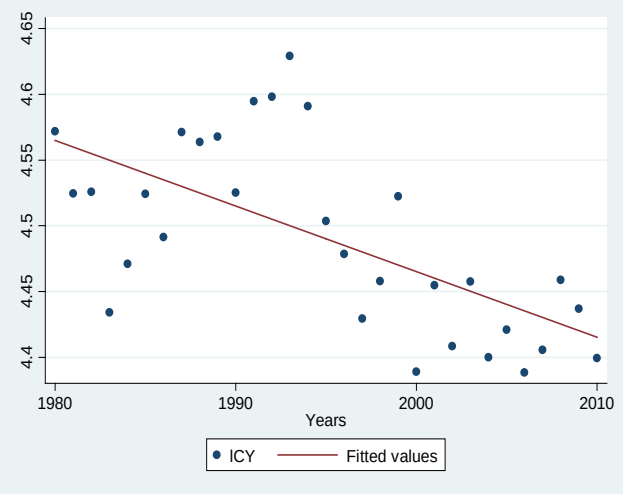


Table 3: Test for Heteroskedasticity- Breusch-Pagan test
Ho: Error term present constant variance- Homoscedasticity

Ha: Presence of Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: ltop lYearsSchool lInd lm2y lgov_exp lFDIY lCY

chi2(7) = 12.45

Prob > chi2 = 0.0867

Variable	chi2	Df	p-value	
Trade openness	1.06	1	0.3029	#
Human capital	2.28	1	0.1314	#
Ind. Value Added	0.44	1	0.5075	#
Monetary Mass (M2)	3.78	1	0.052	#
Gov. Expenses	0.04	1	0.8411	#
FDI	1.24	1	0.2647	#
Consumption share	3.95	1	0.047	#
Simultaneous	12.45	7	0.0867	

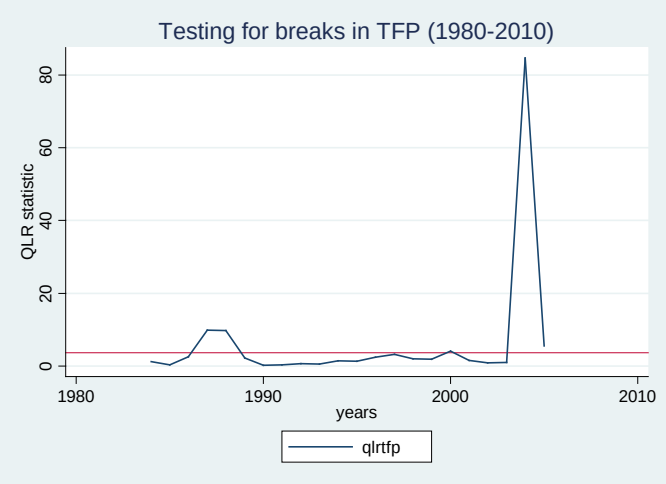
Notes: # unadjusted p-values

Table 4: Non-stationarity- Breaks

(i) Testing for Breaks in TFP (1980-2010): Quandt Likehood ratio (QLR) statistic or Sup-Wad statistic- 5% level of significance.

	years	QLR-TFP
8	1987	9.820235
9	1988	9.741184
21	2000	4.090457
25	2004	84.71101
26	2005	5.487806

Graph 2: Testing for breaks in Total factor productivity data (1980-2010): Quandt Likelihood Ratio at 5% level of Significance.



Notes: 5% level of significance is represented by red line; for values above the line, time-series variable registered a break, in this case, break dates are: 1987, 1988, 2000, 2004 and 2005.

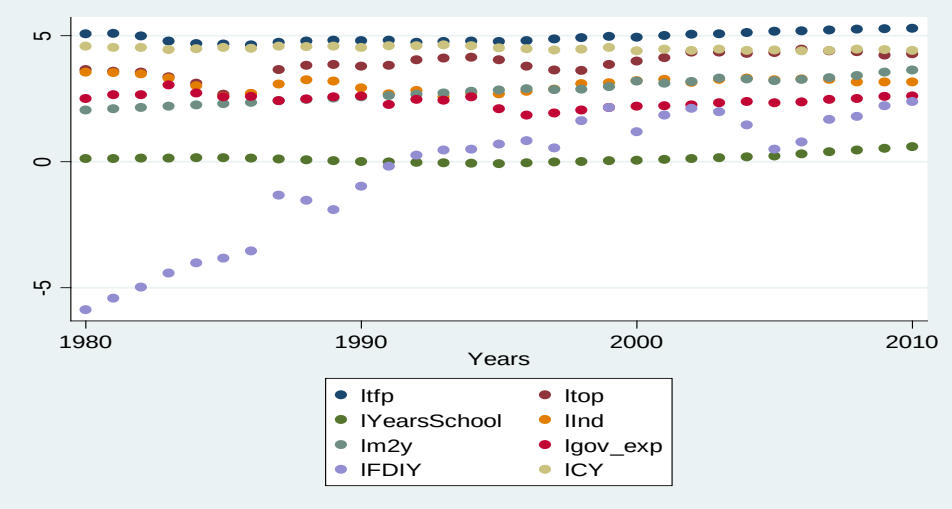
Table 5: Co-integration tests: Johansen tests for co-integration

Trend: constant Number of obs = 29

Sample: 1982 - 2010 Lags = 2

maximum rank	Parms	LL	Eigenvalue	trace statistics	5% critical value
0	72	281.63221	.	299.1372	156
1	87	331.82562	0.96862	198.7503	124.24
2	100	362.32954	0.878	137.7425	94.15
3	111	385.27622	0.79455	91.8491	68.52
4	120	402.79032	0.70117	56.8209	47.21
5	127	415.56773	0.58571	31.2661	29.68
6	132	427.07566	0.54781	8.2503*	15.41
7	135	430.64905	0.21842	1.1035	3.76
8	136	431.20079	0.03734		

Graph 3: Co-integration of model variables: TFP, TOP, YearsSchl, M2y, Ind, Gov_exp, FDIY and CY.



Notes: Total factor productivity (Tfp), Trade openness (Top), average years of schooling (YearsSchl), industry value added to GDP ratio (Ind), Monetary Mass (Money and quasi-money, M2) to GDP (M2Y), government expenditure to GDP ratio (Gov_exp), foreign direct investment to GDP ratio (FDIY), and household consumption to GDP ratio (CY).

Table 6: Optimal Lag: Lag Length Selection

Selection-order criteria

Sample: 1984 - 2010 Number of obs = 27

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	114.997				5.00E-14	-7.92571	-7.81154	-7.54176
1	313.85	397.71	64	0	2.80E-18	-17.9148	-16.8873	-14.4593
2	419.523	211.35*	64	0	6.20E-19	-21.0017	-19.0608	-14.4745
3	.	.	64	.	-1.e-112*	.	.	.
4	6752.51	.	64	.	.	-484.186*	-481.103*	-473.819*

Notes: Endogenous variables are considered: ltfp, ltop, lH, lInd, lm2y, lgov_exp, lFDIY, lCY; Exogenous: _cons.

Table 7: Vector Error-Correction Model: lag(2)

Sample: 1982 – 2010	No. of obs	=	29
	AIC	=	-15.1197
Log likelihood = 306.2357	HQIC	=	-13.83504
Det(Sigma_ml) = 9.29e-20	SBIC	=	-11.01781

(i) Co-integrating equations: Vector Error-Correction Model

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_Total factor productivity	10	0.054257	0.5252	21.01313	0.0210
D_Trade openness	10	0.248369	0.2667	6.909264	0.7340
D_Human capital	10	0.014462	0.9109	194.309	0.0000
D_Ind. Value Added	10	0.164936	0.3768	11.48675	0.3209
D_Monetary Mass (M2)	10	0.047109	0.7595	60.01434	0.0000
D_Gov. Expenses	10	0.162324	0.4100	13.20302	0.2125
D_FDI	10	0.691354	0.3006	8.166764	0.6126
D_Consumption share	10	0.056062	0.2672	6.927377	0.7323

(ii) Co-integrating equation: D_LTtp (first equation of Vector Error Correction Model)

	Coef.	Std. Err.	Z	P>z	[95% Conf.Interval]	
D_Total Factor Produtivity						
_ce1						
L1.	-0.528682	0.2142492	-2.47	0.014	-0.9486028	-0.1087612
Ltfp						
LD.	0.4846888	0.2262237	2.14	0.032	0.0412985	0.928079
Ltop						
LD.	0.008844	0.0667911	0.13	0.895	-0.1220641	0.1397521
lYearsSchool						

LD. lInd	0.767916	0.4282723	1.79	0.073	-0.0714823	1.607314
LD. lm2y	-0.0021683	0.0997223	-0.02	0.983	-0.1976205	0.1932839
LD. lgov_exp	-0.276092	0.218865	-1.26	0.207	-0.7050595	0.1528756
LD. lFDIY	0.0075581	0.0708916	0.11	0.915	-0.1313868	0.146503
LD. lCY	0.0548991	0.0344748	1.59	0.111	-0.0126703	0.1224685
LD.	-0.611555	0.2897129	-2.11	0.035	-1.179382	-0.043728
_cons	-0.0500818	0.0284829	-1.76	0.079	-0.1059072	0.0057437

Notes: Total factor productivity (Tfp), Trade openness (Top), average years of schooling (YearsSchl), industry value added to GDP ratio (Ind), Monetary Mass (Money and quasi-money, M2) to GDP (M2Y), government expenditure to GDP ratio (Gov_exp), foreign direct investment to GDP ratio (FDIY), and household consumption to GDP ratio (CY). The error term θ, is denoted by **ce1,** a negative and statistically significant coefficient means that long term relationship is observed regarding variables in present study.

Cointegrating equations: Vector Error-Correction Model

Equation	Parms	chi2	P>chi2
_ce1	7	1928.061	0.0000

Identification: beta is exactly identified

(iii) Final equation of Vector Error-Correction Model: Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
Total factor productivity	1.0000	.	.	.	.	.
Trade openness	0.1072704	0.0186184	5.76	0.000	0.0707789	0.1437619
Human capital	0.5330562	0.0568376	9.38	0.000	0.4216567	0.6444558
Ind. Value Added	-0.4005594	0.0212535	-18.85	0.000	-0.4422156	-0.3589033
Monetary Mass (M2)	-1.458236	0.0548538	-26.58	0.000	-1.565747	-1.350725
Gov. Expenses	0.115124	0.0303844	3.79	0.000	0.0555717	0.1746763
FDI	0.1632277	0.007503	21.75	0.000	0.1485221	0.1779333
Consumption share	-1.997987	0.1203408	-16.6	0.000	-2.23385	-1.762123
_cons	8.597685	.	.	.	.	.

(iv) Robustness of parameters on D_Ltfp (first equation of Vector Error Correction Model): Long-term relationship

```
( 1)  [D_ltfp]L._ce1 = 0
( 2)  [D_ltfp]LD.ltfp = 0
( 3)  [D_ltfp]LD.ltop = 0
( 4)  [D_ltfp]LD.lYearsSchool = 0
( 5)  [D_ltfp]LD.lInd = 0
( 6)  [D_ltfp]LD.lm2y = 0
( 7)  [D_ltfp]LD.lgov_exp = 0
( 8)  [D_ltfp]LD.lFDIY = 0
( 9)  [D_ltfp]LD.lCY = 0
           chi2(  9) =   20.59
         Prob > chi2 =    0.0146
```

Table 8: Results from VECM: Including and excluding interaction variable between trade openness and total factor productivity, and binary variables.

	VECM									
	VECM (D_LTfp)	VECM	VECM* (D_LTfp)	Interaction term	VECMφ (D_LTfp)	Break dummies	VECM*φ (D_LTfp)	Interaction & Break dummies	Interaction term (1)	Interaction term& Dummy variables (2)
ce1 (error correction)	-0.529**		-0.528**		-0.615*	-	-0.172	-	-	-
	(0.214)		(0.213)		(0.380)	-	(0.284)	-	-	-
LTfp(t-1)	0.485**		0.609**		0.586	-	0.544	-	-	-
	(0.226)		(0.246)		(0.285)	-	(0.399)	-	-	-
Trade openness	0.009	0.107***	0.013	-0.050***	0.114	0.417***	-0.039	0.815***	-0.401***	-1.037***
	(0.067)	(0.019)	(0.102)	(0.014)	(0.111)	(0.037)	(0.166)	(0.029)	(0.084)	(0.211)
Human capital	0.768*	0.533***	1.172	1.699***	2.391	0.819***	-1.944	7.730***	1.541***	6.894***
	(0.428)	(0.057)	(2.775)	(0.269)	(1.590)	(0.176)	(4.274)	(0.734)	(0.301)	(0.816)
Ind.Value Added	-0.002	-0.401***	0.062	-0.152***	-0.027	-0.714***	0.111	-0.815***	-	-
	(0.100)	(0.021)	(0.089)	(0.012)	(0.135)	(0.038)	(0.113)	(0.008)	-	-
M. Monetary (M2)	-0.276	-1.458***	-0.095	-1.405***	-0.420	-0.737***	0.173	0.136***	-	-
	(0.219)	(0.055)	(0.205)	(0.026)	(0.397)	(0.122)	(0.285)	(0.051)	-	-
Gov. Expenses	0.008	0.115***	0.069	0.168***	-0.154	-0.121***	-0.102	-0.609***	-	-
	(0.071)	(0.030)	(0.082)	(0.016)	(0.107)	(0.037)	(0.193)	(0.014)	-	-
FDI	0.055	0.163***	0.058	0.204***	-0.003	0.051***	-0.037	-0.012**	-	-
	(0.034)	(0.008)	(0.036)	(0.004)	(0.025)	(0.012)	(0.038)	(0.005)	-	-
Consumption share	-0.612**	-1.998***	-0.188	-0.662***	-1.118*	-2.814***	-0.395	-2.312***	-	-
	(0.290)	(0.120)	(0.256)	(0.067)	(0.630)	(0.173)	(0.547)	(0.061)	-	-
Ltrade_YearsSchl	-	-	-0.290	-0.305***	-	-	0.640	-1.609***	-	-
	-	-	(0.670)	(0.061)	-	-	(0.880)	(0.158)	-	-
Dummy 1	-	-	-	-	-0.123	-0.158***	-0.117	-0.470***	_	-
	-	-	-	-	(0.088)	(0.034)	(0.132)	(0.017)	_	-
Dummy 2	-	-	-	-	-0.107	-0.190***	0.026	-0.547***	_	-
	-	-	-	-	(0.121)	(0.027)	(0.106)	(0.013)	_	-
Dummy 3	-	-	-	-	-0.080	-0.172***	-0.060	-0.298***	_	-
	-	-	-	-	(0.093)	(0.041)	(0.104)	(0.011)	_	-
Cons_	-0.050	8.598	-0.038	2.204	0.039	10.845	0.007	6.354	_	-
	0.028	-	0.024	-	(0.029)	-	(0.024)	-	_	-
Adj R squared	0.525	-	0.548	-	0.479	-	0.449	-	-	-
No. of obs.	31	31	31	31	31	31	31		-	-

Notes: In parentheses are standard errors. The VECM (D_LTFP) regression represents the first co-integrated equation generated in relation to LTFP (has the correction error term negative and statistically significant; and first lag of Log of Total factor productivity). For VECM (D_LTFP)* regression, interaction term of trade openness and human capital (LTop*LYearsSchl) is included. For VECM (D_LTFP)ψ regression, break dummy variables are

included (dummy1 for 1988, dummy2 for 2000 and dummy3 for 2005). For VECM (D_LTFP)*ψ regression, interaction term and break dummy variables are included (dummy1 for 1988, dummy2 for 2000 and dummy3 for 2005).Last two columns shows total coefficient for trade openness and human capital, when including interaction term (1) and when including both interaction term and break dummy variables (2). The significance levels of 1%, 5% and 10% are represented by ***, ** and * respectively.

Table 9: Granger Causality Wald tests
Ho: There is no Granger-causality of one variable in the other.

Equation	Excluded	chi2	Df	Prob>chi2
Ltfp	Ltop	2.0823	2	0.353
Ltfp	lYearsSchool	4.0821	2	0.130
Ltfp	lInd	0.81596	2	0.665
Ltfp	lm2y	3.6523	2	0.161
Ltfp	lgov_exp	5.4165	2	0.067
Ltfp	lFDIY	2.8514	2	0.240
Ltfp	lCY	3.9175	2	0.141
Ltfp	ALL	135.14	14	0.000
Ltop	Ltfp	4.743	2	0.093
Ltop	lYearsSchool	13.505	2	0.001
Ltop	lInd	2.7557	2	0.252
Ltop	lm2y	4.8662	2	0.088
Ltop	lgov_exp	6.423	2	0.040
Ltop	lFDIY	2.8404	2	0.242
Ltop	lCY	0.74514	2	0.689
Ltop	ALL	70.35	14	0.000
lYearsSchool	Ltfp	17.535	2	0.000
lYearsSchool	Ltop	3.548	2	0.170
lYearsSchool	lInd	5.148	2	0.076
lYearsSchool	lm2y	3.1812	2	0.204
lYearsSchool	lgov_exp	7.4126	2	0.025
lYearsSchool	lFDIY	2.5524	2	0.279
lYearsSchool	lCY	9.3798	2	0.009
lYearsSchool	ALL	72.043	14	0.000
lInd	Ltfp	16.59	2	0.000
lInd	Ltop	9.1707	2	0.010
lInd	lYearsSchool	2.6434	2	0.267
lInd	lm2y	3.0612	2	0.216
lInd	lgov_exp	1.5743	2	0.455
lInd	lFDIY	5.6883	2	0.058
lInd	lCY	2.8555	2	0.240
lInd	ALL	85.312	14	0.000
lm2y	Ltfp	10.209	2	0.006
lm2y	Ltop	3.9063	2	0.142
lm2y	lYearsSchool	6.5441	2	0.038
lm2y	lInd	6.344	2	0.042
lm2y	lgov_exp	1.9227	2	0.382
lm2y	lFDIY	24.653	2	0.000
lm2y	lCY	1.1387	2	0.566
lm2y	ALL	63.745	14	0.000
lgov_exp	Ltfp	5.3066	2	0.070
lgov_exp	Ltop	7.5026	2	0.023
lgov_exp	lYearsSchool	10.13	2	0.006
lgov_exp	lInd	7.4123	2	0.025

lgov_exp	lm2y	0.09499	2	0.954
lgov_exp	lFDIY	7.7366	2	0.021
lgov_exp	lCY	18.184	2	0.000
lgov_exp	ALL	90.024	14	0.000
lFDIY	Ltfp	0.48728	2	0.784
lFDIY	Ltop	0.64822	2	0.723
lFDIY	lYearsSchool	2.8946	2	0.235
lFDIY	lInd	5.0303	2	0.081
lFDIY	lm2y	1.8504	2	0.396
lFDIY	lgov_exp	6.2991	2	0.043
lFDIY	lCY	0.40254	2	0.818
lFDIY	ALL	22.386	14	0.071
lCY	Ltfp	0.02624	2	0.987
lCY	Ltop	5.98	2	0.050
lCY	lYearsSchool	8.9803	2	0.011
lCY	lInd	7.3135	2	0.026
lCY	lm2y	2.5052	2	0.286
lCY	lgov_exp	4.6853	2	0.096
lCY	lFDIY	2.7823	2	0.249
lCY	ALL	30.971	14	0.006

Notes: Variables are Total factor productivity (Tfp), Trade openness (Top), average years of schooling (YearsSchl), industry value added to GDP ratio (Ind), Monetary Mass (Money and quasi-money, M2) to GDP ratio (M2Y), government expenditure to GDP ratio (Gov_exp), foreign direct investment to GDP ratio (FDIY), and household consumption to GDP ratio (CY). Variables are presented in Logarithms.